Procedures and Guidelines

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PREFACE

P.1 PURPOSE

The Mechanical Systems Division (MSD) Safety Manual is intended to establish the policies, procedures, and requirements of the MSD safety program, and to provide GSFC personnel contacts. It summarizes the required safety information needed to conduct activities in the MSD facilities. This Manual lists the pertinent NASA, GSFC, and Occupational Safety and Health Act (OSHA) requirements documents. It is not intended to replace any of the above documents. For more detailed information, the reference documents listed in each section must be consulted.

P.2 APPLICABILITY

This Manual applies to all GSFC organizational elements, contractors, commercial projects, and personnel from other Government agencies while in MSD facilities. The Manual sets the minimum requirements needed to conduct safe operations.

P.3 AUTHORITY

NPG 8715.3, NASA Safety Manual
OSHA 29 CFR 1910, Occupational Safety and Health Standards

P.4 REFERENCES

Each section list the unique reference documents applicable for that section.

P.5 CANCELLATION

5405-048-98, Mechanical Systems Center Safety Manual, Volume I

P.6 SAFETY

This Manual sets forth the requirements for conducting safe operations within the Mechanical Systems Division (MSD), Goddard Space Flight Center (GSFC), Greenbelt, Maryland and Wallops Flight Facility (WFF), Virginia. It defines the requirements, responsibilities, and authorities for all activities conducted within the MSD facilities, and it delineates policies, processes, and approvals for those activities, including Buildings 4, 5, 7, 10, 15, 29, 30, 302, 303, 304, and 305 and WFF D-101, E108, F-7, F-8, F-10, N-159, and X-55.

Although this Manual does not specifically list the NPG 8715.3, *NASA Safety Manual* in each section of the Manual, it is understood that NPG 8715.3 sets the requirements for the overall safety program, which will always be followed. Cross-referenced section numbers, which point to more detailed information on a subject within the document, are enclosed in parentheses. The reader should check the table of contents and index for additional information on a particular subject.

This Manual is arranged to benefit both local facility users and personnel coming into the MSD from outside the organization. It is divided into two volumes for ease of use: Volume 1 contains Sections 1.0 through 3.0 and Volume 2 contains Section 4.0. These sections contain the following information:

- Section 1.0 is an overview of responsibilities and generic information that applies throughout the Manual.
- Section 2.0 provides information needed to answer specific checklist questions contained in the MSD System, Subsystem or Equipment Evaluation Form (Work Instruction 09-PC-WI71, Safety Evaluation Process on web site http://sheds.gsfc.nasa.gov/iso9000/549isohome.htm.) For convenience, Section 2.0 topics are arranged in the same sequence as they appear on the Evaluation Form. As a further aid, Appendix A provides a cross-reference of Evaluation Form checklist items to this Safety Manual's corresponding Section Numbers.
- Section 3.0 describes other MSD general operating requirements over and above those specific topics addressed in the Evaluation Form.
- Section 4.0 (located in Volume II) describes safety issues pertaining to individual MSD facilities.

P.7 TRAINING

Any required training is listed in the applicable section.

P.8 RECORDS

Record Title	Record Custodian
Non-ionizing Radiation Systems, forms GSFC 23-6RF, 23-28RF, 23-6L, 23-28L, and 23-35LU	GSFC Health Physics Office
Ionizing Radiation Systems, forms GSFC 23-6I, 23-28I, 23-35IP, 23-6ID and 23-28ID	GSFC Health Physics Office
Flight Weight Pressure Systems Formal Certification Report	MSD Branch Head
Medium Weight Pressure Systems Formal Certification Report	MSD Branch Head
Hot Work Permit forms GSFC 23-4 and 23-4A and Utility Outage Request Form	Issuing Organization
Confined Space Entry Permit form GSFC 23-52	Issuing Organization
Hazardous Waste Disposal form GSFC 23-54	Hazardous Waste Environmental Office
Incident or Mishap NASA Form 1627A and NASA Form 1627	Issuing Organization

P.9 METRICS

None

P.10 DEFINITIONS

Ω	ohm
µ	micro
ac or AC	alternating-current
ACGIH	American Conference of Governmental Industrial Hygienists
AETD	Applied Engineering and Technology Directorate
AGMA	American Gear Manufacturer's Association
amu	atomic mass units
ANSI	American National Standards Institute
APT	automatically programmed tool
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
°C	degrees Celsius
CFM	cubic feet per minute
CG or cg	center of gravity
c	centi
CMAA	Crane Manufacturer's Association of America, Inc.
CPR	cardiopulmonary resuscitation
CTD	cumulative trauma disorder
CTS	carpal tunnel syndrome
dB	decibel
dc or DC	direct-current
DOT	Department of Transportation
EDM	electrical discharge machine
EED	electro-explosive device
EMC	electromagnetic compatibility
EMI	electromagnetic interference
ESD	electrostatic discharge
ETU	engineering test unit
°F	degrees Fahrenheit
FMD	Facilities Management Division
FMEA	failure modes and effects analysis
FOM	Facility Operations Manager
ft	feet
g	gram
g	unit of acceleration (9.81 m/sec^2)
GFCI	ground fault circuit interrupter
GHB	Goddard Handbook
GHz	gigahertz
GMI	Goddard Management Instruction
GN_2	gaseous nitrogen
GND	ground

GSE	ground support equipment
GSFC	Goddard Space Flight Center
HCC	High Capacity Centrifuge
HOPs	Hazardous Operating Procedures
HVAC	heating, ventilation, and air conditioning
Hz	Hertz (cycles per second)
IDLH	Immediately Dangerous to Life or Health
IEEE	Institute of Electrical and Electronic Engineers
IR	infrared radiation
ISI	inservice inspection
k	kilo
K	degrees Kelvin
kpa	kilopascal
lb	pound
lb/ft^2	pound/square foot
LDE	lifting devices and equipment
LEV	local exhaust ventilation
LFL	lower flammable limit
LN_2	liquid nitrogen
m	milli or meter
M	mega
MAWP	maximum allowable working pressure
MDP	maximum design pressure
MGSE	mechanical ground support equipment
MIL STD	Military Standard
MOI	moment of inertia
MSD	Mechanical Systems Division
MSDS	Material Safety Data Sheet
n	nano
NC	numerically controlled
NDT	Nondestructive testing
NEC	National Electrical Code
NFPA	National Fire Protection Association
Ni-Cd	nickel-cadmium
NIOSH	National Institute for Occupational Safety and Health
NHB	NASA Handbook
NSS	NASA Safety Standard
OEM	original equipment manufacturer
OHA	operating hazard analysis
OSHA	Occupational Safety and Health Act
pa	Pascal
PEL	permissible exposure limit
PETS	payload environmental transport system

psi	pounds per square inch
psig	pounds per square inch gauge
PPE	personal protective equipment
PSTL	Project Support Team Lead
PV/S	pressure vessels and systems
RBO	regulator burnout
RECERT	Recertification Program
RF	radio frequency
RFI	radio frequency interference
RMSS	Remote Manipulator System Simulator
RPO	Radiation Protection Officer
RWA	reaction wheel assembly
S&EB	Safety and Environmental Branch
SCA	Spacecraft Checkout Area
SED	stored energy device
SES	Space Environment Simulation
SLM	sound level meter
SMTF	Spacecraft Magnetic Test Facility
SO_2	sulfur dioxide
SPL	sound pressure level
SSDIF	Spacecraft Systems Development and Integration Facility
T	temperature
T/H	temperature humidity
T/V	thermal vacuum
TCU	thermal conditioning unit
TIG	tungsten inert gas
TLV	threshold limit value
TLV-C	threshold limit value—ceiling
TLV-STEL	threshold limit value—short-term exposure limit
TLV-TWA	threshold limit value—time-weighted average
UL	Underwriter's Laboratories
UV	ultraviolet
VDT	video display terminal
w	watt
WFF	Wallops Flight Facility

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List of Figures and Tables—Volume 1

1.0 Introduction

Safety, in the context of this document, represents the efforts to identify and minimize the hazards associated with operations in the Mechanical Systems Division (MSD). This document provides all personnel operating in the MSD facilities the requirements established for their safety. It is our goal to meet these safety requirements with minimum impact to operations.

1.1 Policies

It is the policy of the MSD to provide a safe work place for all personnel and operations. MSD strives to eliminate or reduce all potential hazards, thereby avoiding undue risk and accidents that can result in loss of life, injury to personnel, damage to property, or loss of operating time and effectiveness. Safety shall always take precedence over operations or schedule. Where hazards cannot be eliminated, engineering controls, personal protective equipment (PPE), and controlled areas shall be used to protect personnel, equipment, and facilities.

1.2 Responsibility

Safety is everyone's responsibility. The MSD Chief has the overall responsibility for all activities conducted in the MSD facilities. Acting for the Chief, the Code 540 Branch Heads are responsible for the comprehensive MSD Safety Program aimed at preventing accidents and reducing injuries. On a day-to-day basis, line supervisors—including associate heads and section heads—are responsible for ensuring compliance with this document and other applicable safety and health standards. Additional duties of line supervisors include the following:

- Inform their employees of safety and health requirements, and of their rights and responsibilities.
- Identify hazardous areas and situations, and verify corrective action is taken.
- Approve all operations conducted by their employees.
- Ensure employees have the proper certifications, training, and personal protective equipment (PPE) required for the tasks assigned.
- Immediately report all significant accidents (requiring more than first aid) and near misses (could have caused death or serious injury) to the Branch Head and GSFC Safety and Environmental Branch (S&EB).

Each building or complex has an appointed Facility Operations Manager (FOM). The FOM's responsibilities as delineated in GMI 1700.2, GSFC Health and Safety Program are to do the following:

- Identify hazards not adequately controlled by the line supervisor. The FOM has the authority to stop work where risk to personnel, facility, or equipment is unacceptable.
- Initiate action to correct or control hazards.
- Ensure that Facilities Management Division (FMD) safety plans for work within their jurisdiction are adequate and comply with this Manual. Questions the FOMs have as to safety requirements shall be directed to the S&EB.

- Approve and issue emergency evacuation plans for the facility, and monitor the designation and indoctrination of building evacuation wardens.

The Applied Engineering and Technology Directorate (AETD) Safety Committee, chaired by the AETD Safety Manager, meet on a monthly basis. Each branch has representatives whose responsibilities are to:

- Exchange and disseminate safety information.
- Assist supervisors in ensuring that employees are properly certified and trained for tasks assigned.
- Assist supervisors in correcting safety discrepancies and, when unable to correct them, notify the appropriate supervisor.
- Report the status of safety discrepancies to supervisors.
- Report all significant accidents, incidents, or near misses to the S&EB and Branch Heads.

Each individual—including GSFC government personnel, personnel from other government agencies, and contractors—is responsible for complying with this Manual and identifying and correcting hazardous situations when noted. They should correct unsafe conditions if it is within their ability to do so. If they cannot correct the situation, they should ensure that the area is secure, to prevent harming others or damaging equipment, and notify their supervisor.

Flight project management or Product Design Leads (PDL) are responsible for assuring their team safety when working within the MSD complex. They shall assess the hazards inherent in their operations and hardware, mitigating all hazards to the lowest level. They are responsible for informing all other groups working on or within close proximity of their operations or hardware of any known hazards.

1.3 Personnel Certification/Qualification Definitions

Personnel must be trained in the special skills, technical knowledge, and safety requirements necessary to perform their jobs and operate facilities, systems, and machines within the MSD. Unless specifically noted otherwise, the following personnel certification and qualification definitions apply throughout this Manual:

- Authorized or Designated—An individual who has been selected or assigned by the Branch or organization management as being qualified to perform specific duties.
- Certified—An individual who has completed required training and whose specific knowledge or proficiency in a skill has been demonstrated and documented by the Authority Having Jurisdiction.
- Competent—An individual who is capable of identifying existing and predictable hazards in the working environment, or working conditions which are dangerous to personnel, and who has authorization to take prompt corrective measures to eliminate them.
- Critical—An individual who has the duties and responsibility to make decisions that could affect the safety of personnel, hardware, or facilities; or one who is working critical operations, such as assembling high dollar value equipment. Examples of critical persons are task leaders and critical crane operators.
- Qualified—An individual who, by possession of a recognized degree, certificate, or professional standing, or knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems related to the subject matter, the work, or the project, or to satisfactorily operate a facility, system, or machine. The Branch or organization management determines necessary qualifications according to the assigned task.
- Training—An organized and documented program of activities designed to impart the knowledge and skills required to be qualified to perform specific duties.

1.4 Waivers

Compliance with the requirements of this Manual is mandatory unless an approved waiver has been obtained from the Chief of MSD. Waiver requests for other GSFC Safety Program requirements and/or policies must be prepared and submitted to the authority having jurisdiction for process and approval.

1.5 Mishaps/Incidents

All mishaps and incidents must be reported to S&EB and investigated using the NASA mishap reporting system. Definitions of mishaps, investigation requirements, and instructions for completing the required forms may be found in Appendix B. Mishaps and closecalls will be assessed to determine where improvements in the safety program are required. Section 1.13 describes the continuous improvement process.

1.6 Emergency Evacuation

1.6.1 General

Any time evacuation alarms sound in the facilities, personnel are to evacuate. Emergency Act Plan for GSFC are found on web site http://safety1st.gsfc.nasa.gov/emp.html. To have personnel remain on station during critical testing (one which sudden shut down could damage critical hardware), a separate evacuation plan must be submitted and approved by S&EB. The plan must reduce personnel on station and when eminent danger exists totally shut down and evacuation. All guest groups to the MSD facility shall have an evacuation plan for their employees that shall notify the Branch Head and S&EB of anyone needing assistance during emergency situations. Never use the elevators during an emergency. Any planned deviations to this procedure must be arranged beforehand, in writing, with the Branch Head and S&EB.

1.6.2 Non-Life-Threatening Emergency

In the event of a non-life-threatening emergency situation:

- Secure the area around the emergency, clearing all personnel except those seriously injured in cases where movement would make the injury worse and the injured is in no immediate danger.
- If the emergency situation can be brought under control without placing personnel in danger, do so.
- Call the Emergency Console (911). Specify the emergency condition, location (building and room), and your name and phone number.
- Designate a specific person to meet the Goddard emergency personnel to inform them of the problem and the status of the situation, and to direct them to the emergency.
- Clean up the area when authorized to do so.

1.6.3 Life-Threatening Emergency

In the event of a life-threatening emergency situation:

- Sound the nearest fire alarm. All personnel shall immediately secure their equipment and evacuate to the designated evacuation area. Stay at least 100 feet from the building, out of the road.
- Go to the nearest safe telephone and call the Emergency Console (911). Specify the emergency condition, location (building and room), and your name and phone number.
- If conditions permit, divert personnel from the hazardous area until trained personnel arrive.
- Designate a specific person to meet the emergency response personnel to inform them of the problem and status of the situation, and direct them to the emergency.

- Buildings 10 and 7 high bays have emergency exhaust fans, which may be activated.
- Re-enter only when told to do so by the emergency response personnel or Fire Department.
- Evacuation is required any time alarms sound longer than 30 seconds.

1.6.4 Area Alarms

The following are the various alarms that may be heard with the Building 7/10/15/29 Complex and the response required.

- Fire/evacuation throughout area - evacuate the building. Call 911.
- Oxygen alarm – local pulsating, high pitched beeping, evacuate the area immediate area. Call 6-8363.
- Process water located on building 7 lab floor, building 7 room 150, basement of building 7 and basement of building 10 – local buzzer which area maintenance group responds to.
- Low airflow within building 29 clean room – start shutting down operations and exit, area maintenance group responds to.

1.7 Construction

Most construction work performed within the MSD facilities is under the control of FMD. When construction work is performed under the direction of Code 540, this document and 29 CFR 1926, *Safety and Health Regulations for Construction*, apply.

1.8 Housekeeping

Although not specifically mentioned in each section, housekeeping is important to the safety of the overall operation. Each person is responsible for cleaning up the work area. Areas not adequately maintained in a clean state not only add to an unsafe condition, but normally affect the quality of the work product.

1.9 Buddy System

The buddy system (two or more persons working together), established for work in hazardous situations, is designed to summon immediate help and provide assistance in case of an emergency. The most important guideline of the buddy system is that the buddy must summon help before providing assistance. When the buddy system is used, at any given time there should always be one individual not exposed to the hazard. The buddy system shall be used on all jobs that involve unprotected height, high voltage, confined spaces, hazardous materials used near or above Immediately Dangerous to Life and Health levels, or any other task that places personnel at extreme risk. When using the buddy system, personnel shall stay within sight of each other.

1.10 Powered Vehicles

Containers of gasoline or gasoline-powered vehicles/equipment shall not be brought inside the buildings. The Branch Head must approve the use of diesel-powered or propane-powered equipment inside the building on a case-by-case basis. If the Branch permits storage of equipment with diesel fuel within the building, a procedure must be followed that verifies the system is not leaking, specifies steps to take if a leak occurs and notifies the S&EB of the location of the fuel.

1.11 Trailers

Trailers supporting operations in the MSD Complex shall not be parked within 40 feet of permanent buildings without approval of S&EB. Trailer housing personnel must be provided fire protection. (See GMI 1710.3, *Trailer Fire Protection*)

1.12 Procedural Requirements

Hazardous operations are those tasks that potentially have an immediate danger to the individual (death or injury) if not performed correctly, could create a danger to other individuals in the immediate area, or are a danger to the environment. These types of operations require written procedures. The procedures must be written in detailed steps to provide maximum protection to personnel, prevent procedural error, and minimize misinterpretation. They must include appropriate warnings and cautions where malfunctions or errors may cause injury or damage. Hazardous procedures must be approved by the appropriate Line Manager or designee and by safety personnel.

1.13 Extended Work Hours

It is MSD policy to establish a limit on the maximum number of consecutive work hours per person to minimize the probability of mishaps due to personnel fatigue. A critical person, or persons involved in critical operations, shall not work in excess of 12 consecutive hours. A maximum of four additional hours (16 consecutive hours) shall be authorized when a one-time emergency circumstance exists, provided that the applicable Branch Head has approved it. Personnel should not work more that 60 hours per week.

1.14 Continuous Improvement

Safety programs are living programs that must change, constantly improving. In order to do this the MSD has implemented area inspections, safety discussions, review of mishaps/close calls, and surveys. Reports are generated when inspections are conducted and open items tracked until closed. Surveys are done to determine employee behavior. When employees are observed violating safety, not only is that employee's behavior corrected, but the overall program is assessed to determine were improvements are needed. Mishap investigations and incident reports are used as a tool to correct problem areas within the program. Monthly discussions are held on safety topics, including close call/mishap reports, survey results, and inspection results.

2.0 MSD Systems Evaluation Form Topics

This section of the Manual is designed to complement the MSD System, Subsystem, or Equipment Evaluation Form (Work Instruction 09-PC-WI71, Safety Evaluation Process on web site http://sheds.gsfc.nasa.gov/iso9000/549isohome.htm.) It is not meant to repeat whole documents that operations/equipment are required to meet, but will summarize the most important aspects of the requirements and ensure the safety of personnel, hardware, and facilities. As a further aid, Figure A-1 in Appendix A provides a cross-reference of Evaluation Form checklist items to this Safety Manual's corresponding Section Numbers.

The evaluation process is described in detail in 09-PC-WI71. This section of the Safety Manual may be used by the project or group to help determine what safeguards/requirements are required for processing/testing, and by the Project Support Team Lead to determine if these requirements have been met. Any remaining questions as to the safety of the test article shall be directed toward the AETD Safety Manager, MSD Safety Lead, S&EB, or Support Contractor Safety Office. Hazardous situations not resolved, or extremely hazardous situations, shall be brought to the attention of the Branch Head. Problem areas not resolved shall call for immediate stoppage of all work.

2.1 Mechanical Handling

2.1.1 Lifting Devices and Equipment (LDE)

2.1.1.1 Scope

This section covers lifting devices, such as overhead cranes, mobile cranes, and hoists.

2.1.1.2 Acronyms/Definitions

1. AGMA—American Gear Manufacturer's Association.
2. ANSI—American National Standards Institute.
3. CMAA—Crane Manufacturer's Association of America, Inc.
4. Critical Lift Coordinator (CLC)—A certified person who directs and gives commands to the Crane Operator during a lifting operation. However, the CLC is not certified to perform rigging and hands-on operations of the crane.
5. Critical Lifts—Lifting operations with special, high-dollar items such as spacecraft, one-of-a-kind articles, or major facility components, whose loss would have serious programmatic or institutional impact. Critical lifts also include operations with special personnel and equipment safety concerns beyond normal lifting hazards.
6. LDE—Lifting Device and Equipment.
7. LDE Certification/Recertification—A process performed by the RECERT Manager, which leads to the initial certification, or continuation of certification, that an LDE is safe for use up to its rated load. The process includes, but is not limited to, LDE compliance and documentation reviews, tests, inspections, nondestructive testing, and analyses.
8. LDE Operator Certification—The documented status of LDE operators validating that they have been trained and are qualified and medically fit to perform lifting and rigging operations in accordance with NASA-STD-8719.9 and have been certified by the RECERT Manager.
9. NFPA—National Fire Protection Association.
10. Noncritical Lifts—Lifting operations that are of a routine, minimal-hazard nature and are governed by standard industry rules and practices.
11. OSHA—Occupational Safety and Health Administration.

2.1.1.3 General

The *Standard for Lifting Devices and Equipment*, NASA-STD-8719.9, establishes minimum safety requirements for LDE used for material handling. Compliance with NASA-STD-8719.9 is mandatory for all NASA-owned, NASA contractor, and visitor-supplied equipment to be used in support of NASA operations.

GPD 8719.9 and GPG 8719.9 define the applicability, policy, and requirements to implement NASA-STD-8719.9 at NASA/GSFC. The following section summarizes the salient requirements of the aforementioned documents.

2.1.1.4 Design/Operational Requirements

1. General Safety Rules for Lifting Operations:
   - Lifting devices shall not be loaded beyond their rated capacity.
   - Prior to an operation, the operator shall review the lifting device Logbook to determine possible impact on planned activity.
   - The operator shall ensure that the LDE certification is current prior to operation.
   - The operator shall establish safety zones before initiating operations. Safety zones should have appropriate barriers (rope, cones, etc.) established prior to lift.
   - The lifting hook shall be connected to facility ground before connecting to explosives or EEDs. (See Section 2.2.4)
   - Keys for access to MSD cranes shall be controlled by the Branch Head.
   - Before starting lifting operation, the operator shall perform a function test and visual inspection. Before starting lifting operations, the operator shall ensure that the hook is centered over the c.g. in such a manner as to prevent swinging or side pulls.
   - When raising loads that approach the rated capacity of the crane, the operator shall test the brakes by raising the load minimally above the surface and holding the load long enough to allow any dynamics to dampen out.
   - If radio communications are to be used, crane operators shall test the communication system prior to the operation. Operation shall stop immediately upon communication loss, and shall not continue until communication is restored.
   - If hand signals are required, only standard signals shall be used, unless preplanned and agreed upon.
   - Loads shall be secured, balanced, and stabilized with proper slings. The use of tag lines may be required to keep the load controlled. Tag line personnel shall use caution not to impart undesirable motion to the load.
   - Person(s) shall not ride the hook or load at any time.
   - Personnel, or any limbs, shall not be located under suspended or moving loads. Waiver for any suspended load operations must be in accordance with the OSHA-approved *NASA Alternate Standard for Suspended Load Operations* and must be obtained through the RECERT Manager.
   - A Critical Lift Coordinator may be in charge of the operation and in his/her pre-lift briefing shall instruct all personnel involved about the positioning and moving to be done. The Critical Lift Coordinator is separate from the Crane Operator/Rigger.
   - An operator shall be at the crane controls at all times while a load is suspended (OSHA requirement). Due to the length of some NASA operations, an operator change may be required while a load is suspended. This shall be accomplished via a procedure.
   - Outdoor hoisting operations should not start if winds are above 20 knots steady state or if gusts exceed 35 knots.

- Flight hardware should not be hoisted during a storm warning condition Code 3 (power outage could occur), unless the stoppage of cranes and other handling equipment due to a power failure cannot result in a condition unacceptable to the Project or MSD Managers. A waiver approved by the applicable Branch Head is required to hoist critical hardware during a Code 3 storm warning. The requesting organization shall make provisions to guard the suspended load until power is restored.
- If a crane fails to respond, notify the RECERT Group.

2. Equipment Certification:
   - GPD 8719.9 and GPG 8719.9 establish the policy and requirements that lifting devices and equipment to be used for material handling service at GSFC are required to be certified/recertified by the RECERT Manager.
3. Critical lift requirements include the following:
   - LDE shall be certified for critical lifts.
   - Operators must be certified for critical lifts.
   - Stress analysis must be performed.
   - Lift stability analysis must be performed.
   - Safety analysis must be performed.
   - Special lift procedures (technical operating procedures) must be followed.
4. Noncritical Lift:
   - LDE shall be certified per NASA-STD-8719.9 for noncritical lifts.
   - Operators, as a minimum, must be certified for noncritical lifts.
5. Personnel Training/Certification:
   - Only operators certified (licensed) by the RECERT Manager are authorized to operate GSFC cranes. Personnel certification process includes formal training, written test, medical examination, and practical demonstration.
   - Operators shall have licenses in their possession when performing lift operations.
6. Safety Variances:

In the event that a mandatory NASA LDE requirement cannot be met, the Flight Project/Division Office shall prepare a safety variance request package in accordance with GPG 8719.9. Safety variances to mandatory NASA LDE requirements shall be approved by the Center Director in accordance with NPG 8715.3, *NASA Safety Manual*. The endorsed waiver/deviation package shall be forwarded to the RECERT Manager for review, approval/disapproval, and other actions as appropriate. OSHA requirements cannot be wavered.

2.1.1.5 GSFC Contacts

RECERT Manager: (301) 286-4209
RECERT Support Function, Manager: (301) 286-5183
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Safety Support Contractor (301) 286-1035

2.1.1.6 Reference Documents Unique to this Section

American Welding Society (AWS) D1.1, *Structural Welding*

ANSI B30.2, *Overhead and Gantry Cranes (Multiple Girder)*

ANSI B30.9, *Slings*

NASA-STD-8719.9, *Standard for Lifting Devices and Equipment*

CMAA Specification No. 70, *Specifications for Electric Overhead Traveling Cranes*

CMAA Specification No. 74, *Specifications for Top Running and Under Running Single Girder Electric Overhead Traveling Cranes*

GMI 1710.6, *Certification and Recertification of Lifting Devices and Equipment, and Critical Lift Requirements*

NFPA No. 70, *National Electric Code*

OSHA 29 CFR 1910.179, *Overhead and Gantry Cranes*

OSHA 29 CFR 1910.184, *Slings*

OSHA 29 CFR 1910.67, *Vehicle-Mounted Elevating and Rotating Work Platforms*

2.1.2 Lifting Assemblies/Components and Load Cells

2.1.2.1 Scope

This section covers the safety requirements to be met when using lifting assemblies and load cells. Lifting assemblies include lift slings and spreader bars, as well as individual lifting components such as shackles, eyebolts, hoist rings, and turnbuckles.

2.1.2.2 Acronyms/Definitions

1. Critical weld—A weld that if removed from the structural sling or component would cause structural failure.
2. Hyrda-set—A manually operated or pneumatic powered hydraulic lifting device designed to incrementally lift and lower critical loads such as space flight hardware.
3. Lift equipment (components)—Components such as wire rope cables, nylon straps, shackles, and hoist rings intended to be used in lifting operations.
4. Lift sling—A lifting device used for hoisting that has one or more legs to attach the load to the lift point.
5. Load cell—A device used to monitor applied load during lifting operations.
6. Nondestructive Testing (NDT)—Methods to examine materials or components in ways that do not impair future usefulness and serviceability of the material or component.
7. Spreader bar—a lifting device used for hoisting that employs a beam or beams to span the attached load and may include the use of a lift sling(s) in the assembly.

2.1.2.3 General

Operations employing lifting assemblies, load cells, and lifting components are considered potentially hazardous, and proper safety precautions must be adhered to at all times. The employee must be certified to use the equipment, and the equipment must be thoroughly inspected prior to each use and possess a clearly visible, current certification tag. Employees must understand the most common hazards of their operation, such as:

- Injuries from falling items due to equipment or hardware failure.
- Injuries from swinging items due to inattention or poor equipment operation.
- Shock, fire, and electrocution from electrical problems.
- Injury from high pressure fluids and gases.

2.1.2.4 Design/Operational Requirements

Employees who work with lifting assemblies, load cells, and lifting components shall be responsible for inspecting them before each use to verify that they are in proper working condition and that they have visible and current certifications. Guidelines for the use of this equipment are as follows:

1. Lifting operations require the use of hard hats except in the specific circumstances described in Section 3.6.4. Safety glasses or goggles must be worn in the presence of flight hardware containing high-pressure fluids with low safety factors.

2. Lifting assemblies, individual lifting components, and load cells shall be certified and affixed with a tag in accordance with GPG 8719.9. The certification tag shall include the following:
   - Assembly or component identification number.
   - LDE category.
   - Rated load.
   - Date due.
   - Inspector's identification.
3. A lift stability analysis and stress analysis is required for all critical lifts. Stress analysis shall verify factors of safety for structural slings to a minimum of either three times yield or five times ultimate. (See NASA-STD-8719.9 for detailed requirements.)

   In general, slings and components must be tested to a factor of 2.0:1 if they are new, repaired, or modified. If a recertification test is performed, it must be to a factor of 1.0:1. When the item is used to lift critical hardware, testing must be performed annually; otherwise, the testing period is every four years. (See NASA-STD-8719.9 for exact testing requirements.) If replacement of a damaged lifting assembly component is required, the replacement must be identical and individually proof tested. The RECERT Manager shall approve all proof test procedures performed in the MSD facility. Incoming hardware shall be inspected in accordance with RECERT requirements. Documentation for hardware that is proof tested and inspected out-of-house, or receive an equivalent Certificate of Compliance, must be submitted to the RECERT Manager for review and certification.

   - If a lift assembly is presented to RECERT for (re)certification with the individual items color-coded, tethered, or otherwise configuration controlled, and there are no plans to disassemble the assembly or rearrange the configuration, then the assembly is load tested as a unit with each item NDT's and one RECERT tag applied.
   - If a lift assembly is presented to RECERT for (re)certification, and the assembly will be disassembled and the individual items are not color-coded, tethered, or otherwise configuration controlled, the assembly may be load tested as a unit or each component load tested individually with each item NDT'd. Load test RECERT tags are applied to each component.
   - If a lift assembly is presented to RECERT for (re)certification, and the configuration will be rearranged, then the assembly is load tested in all applicable configurations with each item NDT'd and one load test RECERT tag per configuration is applied. Note: There may be variations in the number of tags depending upon the similarities among the different configurations.
   - If loose, individual components are presented to RECERT for (re)certification, each component is load test RECERT tagged.

   Regardless of the load testing, NDT tags are applied to each individual item that is NDT'd. NDT is required each time a sling assembly or component is load tested. The minimum NDT required

for critical welds or for those components forming a single failure point in the load path of a sling assembly is a surface examination (MT or PT). All other welds and components of the assembly shall be given a visual NDT as a minimum. Loose, individual components shall be given a surface examination. NDT, including visual inspection, shall be performed by personnel certified in accordance with the requirements of ASNT SNT-TC-1A.

Equipment or hardware that is not affixed with a proper certification and NDT tag, or has a certification date that has expired, is considered uncertified and shall not be used.

Load cells shall be calibrated and tested annually to 100% of safe working load. Eyebolts shall be safety-wired to the load cell to preclude inadvertent disengagement from the cell during use.

4. Basic safety guidelines: Personnel can prevent injuries and payload damage involving the use of lifting assemblies, load cells, and individual lifting components by obeying the following guidelines:
   - Thoroughly inspect each piece of equipment and hardware prior to its use, and report any problems immediately.
   - If you are not certified to use the equipment or hardware, do not use it.
   - If the equipment or hardware is not certified, do not use it.
   - Make sure the equipment or hardware is rated to handle the desired load. If there are any doubts about the rating or the load to be applied, see your supervisor.
   - Wear the proper PPE. Training for PPE must be per Section 3.6.

2.1.2.5 GSFC Contacts

See Section 2.1.1.5.

2.1.2.6 Reference Documents Unique to this Section

See Section 2.1.1.6.

2.1.3 Forklifts

2.1.3.1 Scope

This section covers forklifts for moving equipment and flight hardware.

2.1.3.2 Acronyms/Definitions

1. Equipment Certification—A process performed by the RECERT Support Function, which leads to the initial certification, or continuation of certification, that a forklift is safe to operate up to its rated load for critical materials handling.

2.1.3.3 General

For Institutional Material Handling Equipment (e.g., forklifts) covered by NASA-STD-8719.9, it is NASA's and GSFC's policy to follow standard industry/manufacturer recommended practices and applicable Federal, State, and local government regulations. The forklifts that are designated for critical materials handling shall be inspected and certified by the RECERT Manager.

2.1.3.4 Design/Operational Requirements

1. Equipment Certification:
   - Only forklifts designed, constructed, and inspected in accordance with ANSI B56.1 shall be used on MSD properties. Forklifts are required to be inspected annually.
   - Fork extensions, if required, must be obtained from the Original Equipment Manufacturer (OEM). No modification to equipment is allowed without written OEM approval and documentation.
   - All MSD forklifts that are designated for critical operations are formally certified/recertified and tagged by the RECERT Manager.
2. Operator Training and Medicals:
   - Only trained and qualified operators shall be authorized to operate MSD forklifts. Refresher training shall be performed every year. Training and qualification shall be documented by the operator's supervisor. Medical examinations are required every three years.
3. General Requirements:
   - Approved forklifts shall bear a label/identifying mark indicating approval by the testing laboratory.
   - Capacity, operation, and maintenance instruction plates, tags or decals shall be changed according to documented OEM-approved modifications/additions.
   - Forklifts shall be marked to identify front-end attachments, other than factory installed units, to indicate the revised rated capacity of the lift/attachment combination at maximum elevation with the load laterally centered.
   - Name plates and markings shall be maintained in place and in a legible condition.

4. General Safety Rules:

   - The operator shall perform a daily inspection prior to the first use each day. Defects when found shall be reported immediately to the RECERT Support Function and corrected.
   - Verify that the transported load, including the transporter, does not exceed the allowable floor or hatch loading. Check with the area supervisor to determine the weight restrictions on floors and hatches.
   - Diesel-powered or propane-powered vehicles are not allowed inside the building beyond the truck locks without FOM approval. The use of gasoline-powered vehicles inside the truck locks or buildings shall be approved by the FOM on a case-by-case basis.

2.1.3.5 GSFC Contacts

See Section 2.1.1.5.

2.1.3.6 Reference Documents Unique to this Section

OSHA 29 CFR 1910.178, *Powered Industrial Trucks*

ANSI B56.1-1969, Part II, *American National Standard*

Original Equipment Manufacturer's Maintenance Manuals and Recommendations

See also Section 2.1.1.6.

2.1.4 Mechanical Ground Support Equipment (MGSE)

2.1.4.1 Scope

This section covers MGSE such as dollies, tables, jacks, stands, and other hardware used to transport, orient or support payloads, fixtures, or any other item employed in the integration and test complex.

2.1.4.2 Acronyms/Definitions

N/A

2.1.4.3 General

Certain MGSE may use electrical and/or hydraulic power to orient a payload or fixture that is mounted to it. The MGSE must be thoroughly inspected prior to use and the user must be fully cognizant of its proper operation. Employees must also understand the most common hazards of their operation, such as:

- Injuries from contact with unguarded areas of operation, such as rotating shafts and crush points.
- Shock, fire, and electrocution from electrical problems.
- Injury from high-pressure fluids.
- Injury caused by defective equipment, structural failure, or improper use of the equipment.

MGSE is also intended to be moved throughout the facilities on casters or air-bearing support assemblies and to be raised or lowered with jacks, and the employee must understand the most common hazards of these operations, which are:

- Collision of moving MGSE with the employee and the resultant injury.
- Collision of moving MGSE with hardware or equipment located in the facility and the resultant personal injury due to indirect causes.
- Injury from high pressure gases.
- Crushing injury caused by defective jacks or stands.

2.1.4.4 Design/Operational Requirements

Employees who work with MGSE shall be responsible for inspecting the equipment before use to verify it is in proper working condition, and for being thoroughly familiar with the equipment's proper operation. Guidelines for the use of MGSE are as follows:

1. Always wear PPE (Section 3.6) appropriate for the task at hand. Safety glasses or goggles must be worn in the presence of high-pressure fluids and gases unless the system/equipment has been proven stable. Garments that protect the body but are not prone to snagging in moving mechanisms are appropriate.

2.Equipment certification: All MGSE shall be properly certified by the Project Manager, and shall be affixed with a tag or other readily visible identification attesting to this. Tagging requirements are

the same as stated in Section 2.1.2.4 for lifting assemblies. Critical welds shall receive a surface examination as a minimum. Testing is performed to applicable NASA and OSHA standards. Stands and dollies require a one-time proof test of at least 1.25 times the rated load. Any repair or modification to the load-bearing elements of the MGSE requires that testing and certification be repeated. Certification tags shall contain as a minimum the following information:

- MGSE identification.
- Certification document number.
- Test load.
- Rated load.
- Test date.
- Inspections identification.
- Recertification due date.

Personnel shall not use MGSE if any of the following applies: if the equipment does not have a clearly visible and properly prepared certification tag, if it is not being used for its intended function, if it is handling loads greater than it has been certified for, or if it has been damaged or altered and has not been repaired and recertified.

2. MGSE with pressurized and electrical equipment shall follow the safety requirements as stated in the applicable sections of this Manual.
3. Jacks must comply with the regulations contained in OSHA 1910.244, NASA-STD-8719.9 and ASME/ANSI B30.1. Observe the following when working with jacks:
   - Jacks used to lift or support flight hardware or where loss of control could damage flight hardware shall be analyzed, tested and inspected per NASA-STD-8719.9.
   - The jack shall be legibly and permanently marked in a prominent location with its rated load capacity.
   - The manufacturer shall test all new jacks to rated load. All altered, modified, or repaired jacks shall b tested to rated load by the Structural Test Group before use.
   - The operator shall inspect the jack before use, and ensure that the capacity is sufficient to raise and sustain the load.
   - The operator shall watch the stop indicator, which shall be kept clean, in order to determine the limit of travel. The indicated limit shall not be overrun.
   - Once the load is raised, personnel shall crib, block, or otherwise secure the load. Follow the load witl cribbing where practical. Take measures to prevent personnel from working or passing under the loac until it is secured.
   - Ensure that there is sufficient swing area for the operating lever(s).
   - Remove operating levers when not in use to avoid accidental dislocation of the jack and to reduce the tripping hazard.
   - Ensure that operators are instructed as to signals and other procedures for multiple jacks or other special lifts.

- Off-center loading of jacks should be avoided.
- Extenders shall not be used unless authorized by a qualified person.

2.1.4.5 GSFC Contacts

Environmental Test Engineering and Integration Branch, Head: (301) 286-5072
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034

2.1.4.6 Reference Documents Unique to this Section

OSHA 1910.244, *Other Portable Tools and Equipment*

ASME/ANSI B30.1, *Jacks*

NASA-STD-8719.9, *Standard for Lifting Devices and Equipment*

2.1.5 Powered Industrial Trucks

2.1.5.1 Scope

This section covers industrial trucks powered by electric motors or internal combustion engines used for moving equipment and flight hardware. Refer to Section 2.1.3 for forklifts.

2.1.5.2 Acronyms/Definitions

1. Operator Training—The documented status of operators validating that they are trained in the safe operation of tugs, etc.

2.1.5.3 General

For testing and inspecting powered industrial trucks, it is NASA's and GSFC's policy to follow standard industry/manufacturer recommended practices and applicable Federal, State, and local government regulations. However, the powered industrial trucks that are designated for flight hardware handling shall be tested, inspected, and certified by the RECERT Manager.

2.1.5.4 Design/Operational Requirements

1. Equipment:
   - Only tugs designed, constructed, and inspected in accordance with ANSI B56.1 shall be used on MSD properties.
   - Tugs/tractors are inspected, certified, and recertified by the RECERT Manager.
   - Vehicle recertification shall be performed annually.
   - Modification and additions, which affect capacity and safe operation, shall not be performed without the manufacturer's prior written approval. Capacity, operation and maintenance instructions, plates, tags, or decals shall reflect the item's design and construction.
2. Operator Training and Medicals:
   - Only trained operators shall be authorized to operate powered industrial trucks. Refresher training shall be performed every year. Medicals are required every three years.
3. General Requirements:
   - Reference Section 2.1.3.4.

4. General Safety Rules:
   - Follow applicable operating procedures.
   - Defective powered industrial trucks, those in need of repair, or those that are in any way unsafe, shall be taken out of service until they have been restored to safe operating condition.
   - Report all hydraulic leaks to the RECERT Support Function.
   - The operator shall ensure that the vehicle is within the inspection and testing interval by examining the certification tag.

2.1.5.5 GSFC Contacts

See Section 2.1.1.5.

2.1.5.6 Reference Documents Unique to this Section

OSHA 29 CFR 1910.178, *Powered Industrial Trucks*

ASME/ANSI B56.1-1993, Part II, *Safety Standard for Low Lift and High Lift Trucks*

Original Equipment Manufacturer's Maintenance Manuals and Recommendations

See also Section 2.1.1.6.

2.1.6 Hydra-sets

2.1.6.1 Scope

This section covers Hydra-sets.

2.1.6.2 Acronyms/Definitions

1. Hydra-set—A manually operated or pneumatic powered hydraulic lifting device designed to incrementally lift and lower critical loads such as spaceflight hardware.
2. Hydra-set certification/recertification—A process performed by the RECERT Group which leads to the initial certification, or continuation of certification, validating that maintenance, test, or other operational checks have been performed and are current.
3. Hydra-set operator certification—The documented status of Hydra-set operators validating that they have been trained, and are qualified and medically fit to perform lifting and rigging operations in accordance with NASA-STD-8719.9 and certified by the RECERT Manager.

2.1.6.3 General

Hydra-sets shall be used when there is a requirement for precise adjustment when lifting critical hardware and the crane is not rated to the precision required.

2.1.6.4 Design/Operational Requirements

1. Hydra-sets used for critical lifts shall have a 5:1 factor of safety, based on the ultimate strength for load-bearing elements.
2. The rated load shall be plainly marked on each Hydra-set.
3. Hydra-sets that have the necessary design features, maintenance/inspection, and test intervals to lift critical loads shall be conspicuously marked so that the operator and assurance personnel can distinguish that the Hydra-set is qualified for critical lift.
4. For best performance, select a Hydra-set so that the intended load is between 20% and 80% of the Hydra-set's capacity.
5. RECERT tags are issued and attached to certified/recertified equipment.
6. Only certified (licensed) operators are authorized to operate GSFC Hydra-sets. Training shall include the properties of Hydra-sets, operating procedures, hands-on training, and an operational demonstration.
7. RECERT Hydra-set checkout/return standing procedures must be followed, including completion of the Logbook.
8. Check all components for certifications: hoses, Hydra-set, console, and lifting hardware.
9. Pneumatic Hydra-set flex-hoses shall be secured at the ends.

2.1.6.5 GSFC Contacts

See Section 2.1.1.5.

2.1.6.6 Reference Documents Unique to this Section

Operating Instruction—Remote control Console, Mefco Sales and Service, Inc.

DEL PUB 82-1, *Hydra-set, CC1-300 Remote Control Console Accessory Unit, Auxiliary Hoist Control*

NASA-STD-8719.9, *Standard for Lifting Devices and Equipment*

GMI 1710.6, *Certification and Recertification of Lifting Devices and Critical Lift Requirements*

See also Section 2.1.1.6.

2.2 Ordnance

2.2.1 Scope

This section describes the requirements for ordnance brought into or used within the MSD facilities.

2.2.2 Acronyms/Definitions

1. Class 1.4—Consists of explosives that present a minor explosion hazard (moderate fire, no blast). The explosive effects are largely confined to the package and no projection of fragments is expected. An external fire must not cause instantaneous explosion of almost the entire contents of the package.
2. Electro-Explosive Device (EED)—A device containing some reaction mixture (explosive or pyrotechnic) that is electrically initiated. The output of the initiation is heat, shock, or mechanical action.
3. Electrostatic Discharge (ESD)—An arcing of electric charge across a gap between two points not in contact, or through a nonconductor when the voltage exceeds the dielectric breakdown voltage of the nonconductor.
4. Explosives—Term "explosive(s)" includes any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.
5. Fragmentation—Breaking up of the confining material of a chemical or mechanical mixture when an explosion takes place. Fragments may be complete items, subassemblies, pieces thereof, or pieces of equipment or buildings containing the items.
6. Grounding—The practice of providing an electrical path from an object to ground or the process of connecting one or more conductive objects to the ground.
7. Ordnance—See explosive.
8. Pyroshock test—A test in which the actuation device is a type of electro-explosive device, which imparts a shock to the item under test.

2.2.3 General

The most generally recognized hazard in handling and use of ordnance/explosives is unplanned initiation. The most probable causes of unplanned initiation are as follows:

- Electrostatic hazard—Discharge of static electricity due to possible buildup of a static charge caused by two insulating materials rubbing each other or through moving air or other gasses.
- Lightning hazard—During thunderstorms, statically charged fields can cause static discharge between grounded and ungrounded items.
- Electromagnetic radiation hazard—Situations in which sources are intense and close enough to electro-explosive devices such that current is induced that may cause initiation.

- Mechanical shock hazard—Ordnance becomes pinched or crushed, a hot spot can form which can initiate the explosive, or a severe mechanical shock can fracture the bridge wires, causing the device to fail by not firing.
- Thermal hazard—Exposure to heat may cause detonation rather than deflagration, causing much higher stresses on the device housing.

2.2.4 Design/Operational Requirements

1. The only ordnance or explosives allowed in the MSD Facilities are Class 1.4 or less, unless a waiver is approved by S&EB and the applicable MSD Branch Head.
2. All explosives brought into the facility shall be coordinated with S&EB.
3. Explosives shall not be stored in the MSD Facility unless installed in flight hardware and approved by S&EB. All spare ordnance shall be stored in Building 27A, Explosive Storage Building until needed for specific tests.
4. The fire symbol for fire division 4 (hazard Class 1.4) shall be displayed at the entrance to the work area containing explosives.
5. Explosive operations (working on or with explosives) shall be discontinued as electrical storms approach, and personnel evacuated from the immediate area/room.
6. Containers/hardware containing explosives shall be grounded at all times.
7. Portable ground cables shall be visually inspected prior to each use. Prior to use, it shall be verified that an electrical continuity test has been conducted on the ground cable within the last seven months.
8. Personnel performing installation/hookup operations shall wear static dissipating devices and anti-static clothing/coveralls. Unless conductive flooring is provided, wristats shall be worn. Static dissipating devices shall be checked each time the device is donned to verify the resistance is 1 megohm to 10 megohms.
9. Static generating materials (wools, nylon, silk, plastics, etc.) should be removed from the area containing ordnance.
10. Areas in which ordnance installation operations are conducted shall have at least two separate accessible exits.
11. The buddy system shall be used during ordnance operations.
12. Only personnel necessary to perform ordnance operations shall be present.
13. All personnel involved in ordnance operations shall wear safety glasses or goggles.
14. Autoclaves and other pressure equipment containing explosives or other hazardous chemicals shall be placed in separate cubicles/bays that are designed to confine and direct the force of possible explosions away from personnel and facilities.
15. Operations involving explosives must be separated from those not involving explosives by an approved operational shield or barrier (example: Acoustics Lab reverberant chamber).
16. Operations involving the installation or initiation of ordnance shall be by approved detailed procedure. Procedures shall require that the ordnance be initiated remotely. Procedures must

include a list of approved test equipment by part number and serial number. The appropriate Branch Head or designee shall review and approve the procedure prior to the start of the operation. Testing that includes explosives requires the S&EB approval. The written request shall be submitted at least one week prior to testing and shall include:

- The test procedure.
- Type and number of devices involved (spec sheet preferred).
- Test objective.
- Date of test.
- List of essential personnel.
- List of approved test equipment.
- Test location.

17. Procedures shall incorporate an emergency section that deals with a misfire or hangfire. This section shall require that the test area be secured immediately for a minimum of one hour, and that S&EB be notified.
18. For lifting and handling operations involving explosives, the adequacy of grounding of the crane hook, forklift, container, flight hardware, personnel, and facility should be determined by a qualified electrical engineer.
19. The relative humidity should be maintained at 30% or higher when working with ordnance.
20. No personnel shall be allowed within the hazard area during a pyroshock test.
21. Electrical equipment used for testing EEDs shall be approved by S&EB and the applicable MSD Branch Head. Ohmmeters for measuring resistance of EEDs shall be specially designed for testing pyrotechnic devices. Approved ohmmeters are commonly referred to as "squib checkers," and are designed to limit the current applied to the EEDs. Standard multimeters shall not be used to measure EEDs. Note: If Alinco meters are used, the maximum current output must be checked prior to each use (should be <10ma).
22. Stray voltage tests shall be run on the circuit prior to installation or any electrical hookup of EEDs.
23. Radios or transmitting devices shall not be used near ordnance connection operations.

2.2.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.2.6 Reference Documents Unique to this Section

29 CFR 1910.109, *Explosives and Blasting Agents*

GHB 1720.1, *GSFC Explosives and Pyrotechnic Safety*

NSS 1740.12, *NASA Safety Standard for Explosives, Propellants, and Pyrotechnics*

2.3 Pressure & Vacuum Systems

2.3.1 Ground-Based Pressure Vessels and Pressurized Systems (PV/S)

2.3.1.1 Scope

This section covers ground-based PV/S, including vacuum systems, in permanent or temporary configuration. Appendix C of this Safety Manual contains detailed requirements for PV/S design, modifications, repairs, procurement, etc.

2.3.1.2 Acronyms/Definitions

1. ASME—The American Society of Mechanical Engineers.
2. ANSI—The American National Standards Institute.
3. Ground-Based PV/S—Systems used for ground operations, including pressure vessels, piping, flexible hoses, components for cryogenic service, compressed gases, hydraulic service, and vacuum service.
4. Inservice Inspection (ISI)—On-going RECERT inspections or tests performed on PV/S and components after a system has been certified and put into service.
5. Maximum Allowable Working Pressure (MAWP)—The maximum pressure permissible at the top of a vessel in its normal operating position at the coincident operating temperature.
6. Maximum Design Pressure (MDP)—The maximum pressure permissible for each component in a piping system at the most severe condition of coincident internal or external pressure and temperature (minimum or maximum) expected during service.
7. PV/S Certification/Recertification—A process performed by the RECERT Manager, which leads to the initial certification, or continuation of certification, that a PV/S is safe to operate within specific certification parameters. The process includes PV/S compliance and documentation reviews, tests, inspections, nondestructive testing, and analyses.
8. RECERT—The NASA Recertification Program for periodic certification and/or recertification of ground-based PV/S outlined in NPD 8710.5, NPG 1700.6, and GMI 1710.4.
9. Recertification Program (RECERT) Manager—The RECERT Manager, appointed by the Center Director, has overall implementation, managerial, certification, and recertification responsibility for the Center's RECERT Program for PV/S and Lifting Devices and Equipment.

2.3.1.3 General

All pressure vessels, pressurized components, and pressurized systems (including vacuum systems) in permanent or temporary configuration shall be designed, fabricated, installed, operated, periodically inspected, maintained, repaired, and certified/recertified in accordance with GMI 1710.4.

2.3.1.4 Design/Operational Requirements

1. Certification Policy and Requirements (GMI 1710.4):
   - All PV/S shall be formally certified by the RECERT Manager as safe to operate before initial use and shall be recertified periodically after initial certification.
   - PV/S brought onto GSFC property for temporary use in support of mission or facility operations shall comply with the requirements of GMI 1710.4.
   - The documentation delineated in Attachment A to GMI 1710.4 shall be provided to the RECERT Manager as part of the certification requirements.
2. All ground-based PV/S are subject to RECERT ISI.
3. PV/S Safety Requirements:
   - There shall be no welding on installed PV/S, unless approved by the RECERT Manager.
   - The Branch Office shall notify the RECERT Manager immediately of all deficiencies, incidents, and mishaps involving PV/S.
   - All flex hoses shall be recertified annually by the RECERT Manager.
   - All flex hoses operating at a pressure greater than 150 psig (1,034 kpa) shall be mechanically restrained at each end and every five feet (1.5 m) to prevent whipping in the event of separation. In addition, intermediate restraint shall be provided at any location where two hoses are joined together. Refer to T.O. 00-25-223 for approved restraint details.
   - All compressed gas cylinders shall be within current U.S. Department of Transportation certification.
   - All compressed gas cylinders shall have protective caps installed or be connected to manifolds/regulators and be positively restrained to prevent falling.
   - Pressure gages shall have a one piece shatter-proof window and a blow out back, or equivalent.
   - Pressure gages should be selected such that the maximum operating pressure (MOP) of the system falls within the middle third of the range of the gage. In no event shall a gage be used on a system whose MOP is less than 25% of the gage range, nor greater than 75% of the gage range.
   - In no event shall any pressure system segment or component be disconnected while the system is under pressure. It must be verified that all residual energy has been dissipated prior to disconnection. (Reference Section 3.8, Lockout/Tagout)
   - In no event shall tube fittings be tightened while the system is under pressure.
   - Overpressure Protection Requirements:
     a. All pressure vessels and piping/tubing systems shall be equipped with approved overpressure protection devices.

b. All overpressure protection devices shall be set to function at or below the MAWP of the vessel or MDP of the piping/tubing system.

c. All overpressure protection devices shall be installed so they are readily accessible for inspection and cannot be rendered inoperative.

d. All new relief valves shall have their set points certified by the RECERT Manager prior to being placed in service.

e. Relief valves of adequate capacity shall be installed in all cryogenic piping/tubing segments located between isolation or control valves.

f. The discharge of relief valves located on indoor cryogenic systems must be diverted or piped away from personnel and equipment. Relief valves, which do not provide for attachment of discharge piping/tubing shall not be used.

g. Adjustable type relief valves shall not be used on any piping/tubing system without the prior written approval of the RECERT Manager.

h. No repairs to PV/S overpressure protection devices shall be made.

i. Any repair to a PV/S pressure-indicating gage requires that the gage be recertified prior to reinstallation.

4. PV/S Modifications and Repairs

- System Modifications—All modifications to PV/S void the system's certification. Appendix C contains the requirements that must be met in order for the modified system to be recertified and placed into/returned to service by the system owner.
- System Repairs – Appendix C contains repaired-system recertification requirements.

5. Waivers and Deviations—When the technical requirements of applicable Codes/regulations (with the exception of Federal Regulations) cannot be met, a waiver/deviation request package shall be prepared by the initiating Flight Project/Division Office. Preparation shall be in accordance with NPG 8715.3 and RECERT procedures. The waiver/deviation request package shall be reviewed and endorsed by the initiating Flight Project/Division Office and the Safety and Environmental Steering Committee. The endorsed waiver/deviation request package shall then be forwarded to the RECERT Manager for review, approval/disapproval, and other actions as appropriate.

6. Personnel operating high-pressure systems (>150 psi [1,034 kpa]) must be trained and certified.

2.3.1.5 GSFC Contacts

RECERT Manager: (301) 286-4209
RECERT Support Function, Manager: (301) 286-5183
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Safety Support Contractor (310) 286-1035

2.3.1.6 Reference Documents Unique to this Section

ANSI/ASME Code for Pressure Piping, B31

ANSI/ASME Boiler & Pressure Vessel Code

GMI 1710.4, *Certification and Recertification of Ground-Based Pressure Vessels and Pressurized Systems*

NPD 8710.5, *NASA Safety Policy for Pressure Vessels and Pressurized Systems*

NPG 1700.6, *Guide for In-service Inspection of Ground-Based Pressure Vessels and Pressurized Systems*

2.3.2 Flight Pressure Vessels, Pressurized Systems, and Ground Support Equipment

2.3.2.1 Scope

This section covers those flight-specific PV/S which are brought into MSD facilities for testing and/or integration, and which are not included within the RECERT Program. The requirements for these vessels/systems may be different than the requirements stated in Section 2.3.1 due to a flight project's requirements. Specific examples are:

- Flight-weight pressure vessels and systems,
- Medium-weight pressure vessels and systems, and
- Flight project ground support equipment (GSE): purge carts, engineering test units (ETUs), payload environmental transport systems (PETS), other flight project-specific R&D-type PV/S, etc.

Design, fabrication, test, and certification requirements of these PV/S are covered in GMI-1700.3, or other applicable documents.

2.3.2.2 Acronyms/Definitions

1. Flight-Weight Pressure Vessels—Includes those pressure vessels which cannot be designed, fabricated, or tested to meet the requirements specified in *ANSI/ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1, due to their lighter weight necessary to meet space flight use requirements. These pressure vessels have a nominal design factor of safety of less than 2.5 and are designed, fabricated, and operated in accordance with NSS/HP 1740.1, *NASA Aerospace Pressure Vessel Safety Standard*, and/or other governing documents.
2. Medium-Weight Pressure Vessels—These pressure vessels have a design safety factor within the nominal range of 2.5 to 4.0 on ultimate tensile strength. These vessels may be used for flight operations, ground operations directly associated with flight, or for test purposes where simulation of flight hardware or weight reduction is necessary. Design, fabrication, test, operations, certification, and recertification requirements are contained in NSS/HP 1740.4, *NASA Medium-Weight Pressure Vessel Safety Standard*, and/or other governing documents.

2.3.2.3 General

Although flight pressure systems may have been designed to meet launch site criteria, they may not meet all the requirements for testing and/or integration in the MSD facilities. The purpose of environmental testing performed in the MSD facilities is to verify the systems meet all required design and fabrication criteria.

2.3.2.4 Design/Operational Requirements

1. Certification:

   Prior to arrival at an MSD facility, the project manager shall formally certify to MSD that:
   a. Flight-Weight Pressure Vessels comply with the requirements of NSS/HP 1740.1, or equivalent.
   b. Medium-Weight Pressure Vessels comply with the requirements of NSS/HP 1740.4, or equivalent.

c. GSE Pressure Vessels comply with the requirements of *ANSI/ASME Boiler and Pressure Vessel Code*, Section VIII, regardless of maximum operating pressure.
d. GSE Pressurized Systems comply with the requirements of the appropriate section of ANSI/ASME B31, regardless of maximum operating pressure.

2. Documentation:
   - Flight PV/S—Prior to arrival at an MSD facility, project personnel shall certify that the following items are complete. Copies of applicable documents shall be made available to MSD upon request.
     a. Structural and Stress Analysis.
     b. Fatigue Life Analysis.
     c. Fracture Mechanics Analysis.
     d. Reflown Hardware Analysis (if applicable).
     e. Pre-Proof Pressure Test Inspection.
     f. Proof Pressure Test.
     g. Post-Proof Pressure Test Inspection.
     h. Calibration of gages, regulators, and relief valves.
   - Prior to arrival, Project personnel shall provide copies of the following documents to MSD upon request:
     a. Operating procedures.
     b. Inspection methods and intervals.
     c. Probable location of defects.
     d. Pressure/temperature history.
   - GSE—Prior to use in an MSD facility, project personnel shall certify that the following items are complete. The overall system, as well as individual components within the system, shall be tagged to indicate completion of testing, the due date for recertification testing, and the name of the person who conducted the test. Copies of supporting documents shall be made available to MSD upon request.
     a. System Proof Pressure Test.
     b. System Leak Pressure Test.
     c. Pressure gage calibration.
     d. Relief valve lift set-point verification.
     e. Flex Hose Pressure Test.
3. Recertification—Flight and GSE PV/S shall be recertified at intervals established by the Project in accordance with requirements contained within the applicable code.
4. General Requirements—PV/S safety requirements delineated in Section 2.3.1.4.3 are applicable hereto, with the following additions:
   - Hazardous Operating Procedures (HOPs) shall be prepared prior to performing operations involving PV/S. HOPs shall be approved by MSD prior to use.
   - In the event that a project wishes to perform PV/S proof testing using MSD facilities, the project shall perform an operating hazard analysis (OHA) of the proposed test. OHAs shall be approved by MSD prior to use.

2.3.2.5 GSFC Contacts

MSD, Assistant Chief for Operations: (301) 286-8747
Environmental Test Engineering and Integration Branch, Head: (301) 286-5072
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034

2.3.2.6 Reference Documents Unique to this Section

GMI 1700.3, *Systems Safety for Flight Orbital Projects*

NSS/HP 1740.1, *NASA Aerospace Pressure Vessel Safety Standard*

NSS/HP 1740.4, *NASA Medium-Weight Pressure Vessel Safety Standard*

U.S. Air Force Technical Manual, T.O.00-25-223, *Integrated Pressure Systems and Components (Portable and Installed)*

2.4 Stored Energy Devices

2.4.1 Batteries

2.4.1.1 Scope

This section covers the various types of batteries that are used to power equipment, experiments, and systems brought into the MSD facilities.

2.4.1.2 Acronyms/Definitions

1. Battery or battery pack—A device composed of individual cells connected in series and/or parallel arrangements, and used for the storage and controlled use of electrical energy.
2. Cell—The smallest component of a battery pack, containing a subset of the total power required to run a device.
3. Short circuit—Direct connection of the positive and negative terminals together with no load in the current path.

2.4.1.3 General

The types of batteries used in the MSD can be alkaline, lead-acid, nickel-cadmium, nickel-hydrogen, lithium-ion, or lithium-sulfur. Some are rechargeable and some are non-rechargeable types. The non-rechargeable alkaline and nickel-cadmium button batteries used in watches and calculators are considered safe and will not be discussed here.

2.4.1.4 Design/Operational Requirements

1. The Project is responsible for notifying MSD if non-commercial batteries are present in equipment, experiments, and systems brought into the MSD complex. At a minimum, the Project's test plan shall address the following items when it is expected that battery charging shall take place:
   - Describe the types and number of batteries. Include information concerning all manufacturer safety warnings and precautions for handling, using, and disposing of the batteries.
   - Perform a hazard analysis and describe all steps necessary to mitigate the hazards. If battery hazards are present, describe what warning signs and personnel access controls will be needed in the affected area. If the batteries do not present potential hazards, the test plan shall state this fact.
   - Based on the Project test plan, the Project shall develop step-by-step integration and testing procedures that ensure that all affected personnel know their responsibilities and duties when working on or around systems containing batteries. Personnel shall be informed of all potential dangers and emergency actions.
2. Procurement and Handling—All battery procurements shall be accompanied by a Material Safety Data Sheet (MSDS) and the manufacturer's certification and traceability information. Follow the manufacturer's technical recommendations for packaging, labeling, and shipping batteries.

3. Lead-Acid Batteries—These are the standard batteries that power the forklifts, HCC end cap loader, personnel lifts, tugs, etc. They contain a liquid electrolyte of sulfuric acid and water and have lead plates inside. Operational requirements for lead-acid batteries are as follows:
   - Charge and maintain batteries near an emergency eyewash station and personnel shower. MSD battery charging stations for powered equipment are located in the Buildings 7/10 truck lock, Building 15 high bay near the emergency exit, and in the Butler Building (between Buildings 15 and 77).
   - When handling batteries, use the appropriate PPE to protect the body from contacting the sulfuric acid electrolyte. Use rubber gloves, goggles or full face shields, and safety shoes if lifting heavy batteries. Long sleeved shirts, lab coats, or coveralls provide additional skin protection and can be removed in the event of a spill before acid contacts the skin. If any liquid contacts the body, immediately flood the area with massive amounts of clean water (15 minutes or longer). Do not allow lead or lead deposits to contact the skin. Seek medical attention as required.
4. Nickel-Cadmium Batteries—These batteries are typically used in powered electronic equipment such as portable oscilloscopes, photographic equipment, laptop computers, etc. The electrolyte is a mixture of potassium hydroxide and water. Operational requirements for nickel-cadmium batteries are as follows:
   - When servicing the batteries, wear the appropriate PPE to protect against exposure to the electrolyte, which can cause severe eye irritation and chemical burns to the skin.
   - During short circuit conditions, very high currents may flow, causing damage to the battery and creating heat, which may cause fire. Use class D fire extinguishers on the batteries to extinguish the fire. Use other fire extinguisher types only on surroundings, not on the batteries. Use caution when extinguishing a Ni-Cd battery fire because the smoke is toxic.
   - Battery packs of multiple cell design should be built by the manufacturer and not assembled in the field. The user should not attempt to connect cells in parallel to create a larger capacity battery, because mismatches in current and voltage might create unwanted current flow between the individual battery packs or cells.
   - Ni-Cd batteries can explode if over-charged. If non-commercial charging equipment is used, it should be analyzed to verify inhibits are in place to prevent over-charging. Additionally, these may be pressure vessels and should meet the requirements of Section 2.3.2 if designed and built for use as flight hardware.
5. Nickel-Hydrogen Batteries—Typically these batteries will be used to power spacecraft, experiments, and flight projects. The electrolyte is a diluted alkaline solution. Self-sealing venting is provided to prevent pressure build-up during recharging. These may pose the same hazard as Ni-Cd batteries if over-charged.
6. Lithium-Ion Batteries—This is a battery technology used to power everything from calculators, computers, and camcorders to the cordless HST pistol grip tools, spacecraft, and

satellites. The potential hazards resulting from shorting, over-charging, or over-discharging this type battery include high heat and fires that may release toxic gases.

7. Lithium-Sulfur Batteries—Typically these batteries will be used in spacecraft and flight projects. Before using them, consult and follow the operating precautions contained in the NASA Reference Publication 1099, *Lithium-Sulfur Dioxide Cell and Battery Safety* (latest revision.) The potential hazards resulting from shorting, over-charging, or over-discharging this type battery, include high heat and fires that may release noxious sulfur dioxide gas and/or electrolyte. Also, small quantities of cyanide and methane could be released in a sulfur dioxide-limited (excess lithium) cell.
8. Storing Batteries—Batteries may be stored safely for years if these basic guidelines are observed:
   - Batteries may be stored in an area that must be well ventilated, dry, and cool (under 50 °C). Temperatures must be maintained above those, which would freeze the electrolyte (specified by the manufacturer), to prevent damaging the battery and spilling electrolyte.
   - Batteries should be stored in the original shipping container if possible.
   - Batteries not in the original container should be stored in containers of wood, fiberboard, or plastic designed to prevent contact between batteries.
   - Smoking and creation of sparks around stored batteries shall be strictly prohibited.
   - Fire extinguishers should be class D type for extinguishing fires. If only the water type is available, try to keep the surroundings cool and prevent the spread of flames, but don't aim the water at the batteries because the water could trigger an explosion.
9. Charging Batteries—General guidelines for battery charging operations are as follows:
   - Never smoke or create sparks around charging batteries. It is possible to ignite the hydrogen gas produced during the charging process.
   - When mixing electrolyte for batteries, always pour acid slowly into water. Never pour water into acid because the chemical reaction may run away and cause an explosion.
   - Charge batteries only in well ventilated areas designated for charging. In MSD facilities, these include the truck locks and high bays where emergency eyewash stations and personnel showers are located. The Butler Building (between Buildings 15 and 77) is designated as a battery charging and temporary storage facility. If ventilating fans are available, start them before charging operations.
   - Ensure that the area is well posted with warning and "No Smoking" signs. Rope off the area as required for safety.
   - Never eat food in the charging area, because of the danger of contamination.
   - Wash thoroughly after handling and charging batteries to remove skin irritating contaminants.
10. Using and Discharging Batteries—General guidelines for using and discharging batteries are as follows:

- Be sure the battery is proper for the application. For example, lead-acid batteries that will fly aboard airplanes must be designed not to leak electrolyte regardless of their position.
- Never mix battery types such as Ni-Cd and lead-acid in one application. This can lead to rapid discharge of one battery pack by another, which can lead to fire or explosion.
- Avoid testing batteries in a vacuum, unless designed to do so.
- Always read and follow the manufacturer's recommendations on how to use and recharge a particular type of battery. Ensure that the recharging method and charging rate are correct for the type of battery. For example, charging equipment for lead-acid batteries might cause explosions in nickel-cadmium batteries.

11. Disposing of Batteries—Most batteries used in the MSD facilities should be considered as hazardous waste for disposal purposes. General guidelines are as follows:
    - Never dispose damaged, corroded, or worn-out batteries in dumpsters. Contact the Hazardous Waste Environmental Specialist (x6-9233) for assistance.
    - Do not mutilate or crush batteries. Corrosive electrolytes and acids will be released.
    - Do not incinerate batteries. They will release toxic vapors or explode.
    - Do not create a short circuit to discharge failing batteries before disposal. This can cause arcing or enough heat to start a fire. Discharge slowly through a predetermined load at or below the maximum discharge rate.
    - Do not dispose of batteries in a charged state.

2.4.1.5 GSFC Contacts

GSFC Hazardous Waste Disposal: (301) 286-9233
S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.4.1.6 Reference Documents Unique to this Section

OSHA 29 CFR 1910.178 Section 2g, 1926.441, 1926.400

NASA Reference Publication 1099 (Lithium-Sulfur Dioxide Cell and Battery Safety)

NASA Goddard Space Flight Center Electrical Safety Policy Manual

NASA Goddard Space Flight Center Issuance Information Sheet GHB 1710.5

National Electrical Code, Article 480 Storage Batteries

2.4.2 Mechanical

2.4.2.1 Scope

This section covers mechanical stored energy devices (mechanical SEDs) such as springs, booms, gyros, solar array deployments, reaction wheels, and other types of kinetic or rotational systems.

2.4.2.2 Acronyms/Definitions

1. Reaction wheel—Reaction wheels are large spinning masses that operate at variable rotational speeds.
2. Deployment—In this Manual, a deployment is defined as any system that is stored in one configuration and then opened to another by some forcing mechanism. Examples include solar array and boom deployments and yo-yo de-spins.

2.4.2.3 General

The Project is responsible for informing the MSD Project Support Team Lead of the presence of SEDs that could pose a hazard to personnel or facilities, defining what the potential hazards are, and specifying how the hazards will be mitigated while the payload is in the MSD complex. A major concern is the unplanned initiation of the stored energy system, particularly if it is actuated by an electro-explosive device. Special procedures, and in many cases isolated facilities, are required to integrate and test systems that contain mechanical SEDs.

2.4.2.4 Design/Operational Requirements

1. Personal protective equipment (PPE)—The Project test plan and procedures shall specify what PPE should be worn by personnel who work with mechanical SEDs.
2. Electro-explosive devices (EED)—(See Section 2.2 for specific information on working with payloads that contain EEDs and other ordnance systems.) EEDs are highly controlled and monitored items while they are within the MSD complex.
3. Hazards analysis—The Project shall perform a hazard analysis of all mechanical SEDs and explain how the hazards will be eliminated or mitigated while they are within the MSD complex. The Project test plan shall be approved by the Project Support Team Lead and the applicable MSD Branch before the item is delivered to GSFC.
4. General safety rules—The following guidelines apply to mechanical SEDs:
   - Post signs in the area, warning of the presence and status of mechanical SEDs. Signs shall list the appropriate personnel and phone numbers to call in emergency situations.
   - Keep unauthorized personnel away from the area by using barrier tapes or shields as required. If necessary, a designated monitor shall guard the area and restrict access to authorized personnel only.
   - There shall be locking mechanisms or other structural means to secure deployable parts of a payload to prevent their unplanned activation. For example, spring-actuated devices shall have marmon clamps or other mechanisms that are fastened with structural

hardware rated to a minimum factor of safety of three on yield. Test plans and procedures shall state clearly at what point in the operations it is safe to remove locking mechanisms and arm firing circuits. As a general rule, this should be as close in time to the actual firing as is practical.

- It may be necessary to perform boom deployments or spacecraft separation testing in a controlled area where the walls and structure of the facility provide physical protection. It is possible for pieces of the payload to be ejected at high speed and with great force. Verify that no facility appurtenances such as lighting, piping, wiring, alarm systems, etc., are in the path of ejected pieces. Where analysis requires it, protect all such appurtenances with covers and shields.
- Verify that no flicker detectors, smoke alarms, etc. will be activated inadvertently by the operations. It is possible for rotating or oscillating systems to reflect light intermittently which could send false signals to a flicker detector.
- Personnel must exercise extreme caution when working around or handling payloads that are in the deployed state, since they may be extremely fragile.
- Check overall clearances throughout the facility to verify that all items can deploy without interference. Pay particular attention to wiring and cable harnesses that might have to deploy along with the hardware. Verify that adequate grounding systems are installed and will be effective in the stored and deployed configurations.
- Where possible, proof test deploying and arresting systems with dummy payloads before conducting actual tests. Dummy payloads should simulate actual conditions as nearly as possible, particularly with respect to actual masses and their centers of gravity. Sometimes deployed systems tend to bounce, rotate, or swing in unexpected ways that are more damaging than the shock of deployment.
- To the extent possible, closed circuit television cameras and video recorders (or film cameras) should be used to monitor the status and actuation of mechanical SEDs. Personnel shall be excluded from the immediate area (or from inside the chamber) during actuation of mechanical SEDs, unless the hazards analysis and test plan have documented clearly that there is no potential chance of injury.

5. Reaction wheel assemblies (RWA) and gyros—Some of these devices have large masses that spin at potentially dangerous rotational speeds. Depending on project requirements, the masses may or may not be spinning during a particular test and evaluation phase. The test plan and procedures shall state clearly the anticipated operational status and the precautions required for a given phase. Some general guidelines for reaction wheels and gyros follow:

   - The test plan shall provide a hazards analysis of the device and the precautions that must be taken to eliminate or mitigate the hazards.
   - Each device shall be analyzed for its structural, electrical, thermal, and materials properties. The device housing should be adequate to contain the mass and prevent any parts from being ejected in the event of wheel failure, or the device should be placed in a

secure facility during testing. Mounting bolts and structural hardware shall be analyzed and designed with a minimum safety factor of three on yield.

- In the MSD facilities, the first preference is for the wheels not to be spinning in RWAs and gyros during payload integration and testing, so there is no potential danger to personnel. The second preference is for all personnel to be excluded from being allowed inside the test cell or near the payload if the wheels are to be spinning. The third preference is that if personnel must be near a spinning wheel, the hazard analysis and test plan shall state clearly under what circumstances and with what protective measures this would be allowed. The third option shall be approved by the appropriate MSD Branch Head before the operation is allowed.

2.4.2.5 GSFC Contacts

Environmental Test Engineering and Integration Branch, Head: (301) 286-5072
Project Support Team Lead, Head: (301) 286-5072
S&EB (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety (301) 286-1035

2.4.2.6 Reference Documents Unique to this Section

N/A

2.5 Hazardous Materials and Hazardous Waste

2.5.1 Hazard Communication Program

I. Purpose and Scope

This section of the Safety Manual establishes general policy and procedures for the Hazard Communication Program to inform employees in the Mechanical Systems Division (MSD) of chemical hazards they may be exposed to in the workplace under normal conditions, or in a foreseeable emergency. It describes the requirements for the use of hazardous materials and the disposal of hazardous waste used in the MSD facilities. For convenience, this section is organized in a stand-alone format that can be excerpted as needed by the user.

II. Applicability

The Hazard Communication Program is applicable to all civil servants and contractors working in the MSD facilities. Employees engaged in the laboratory use of hazardous chemicals shall comply with the latest revision of *GSFC's Chemical Hygiene Program* (GPG 1700.2), which outlines the requirements of the *Occupational Safety and Health Administration's Laboratory Standard*, 29 CFR 1910.1450.

III. Policy

The MSD policy is to establish and implement a comprehensive Hazard Communication Program, which fully meets the requirements of the *Hazard Communication Standard* (29 CFR 1910.1200) promulgated by the Occupational Safety and Health Administration (OSHA.)

IV. Responsibilities

Specific responsibility and authority for administering and implementing the MSD Safety Program, including the Hazard Communication Program, are defined in Section 1.2 of this Safety Manual. Additional responsibilities specific to the Hazard Communication Program are defined below:

A. Chief, Mechanical Systems Division has overall responsibility for ensuring that the Hazard Communication Program is implemented in this organization, including the following:

1. Ensure that resources needed to comply with the Hazard Communication Program are available.
2. Ensure that all line managers/supervisors and their employees attend required training.
3. Ensure that new employees are appropriately trained and certified.

B. Branch Heads shall identify and acquire all resources needed to implement the Hazard Communication Program for their areas of responsibility, including the following:

1. Develop, implement, and maintain a written Hazard Communication Program specific to their area of authority that incorporates the requirements outlined in this section.
2. Ensure that Material Safety Data Sheets (MSDSs) for every hazardous chemical in their area are maintained and are readily available to employees in the GSFC Database.
3. Maintain an accurate and current inventory of the hazardous chemicals in their area, and forward the inventory list to the Safety and Environmental Branch at the beginning of each fiscal year.

C. Line Supervisors are responsible for direct action and enforcement to ensure compliance with the Hazard Communication Program, including the following:

1. Maintain readily accessible copies of MSDSs for each hazardous chemical in the GSFC Database.
2. Maintain an accurate inventory of the hazardous chemicals used in the workplace.
3. Ensure that containers of hazardous chemicals are appropriately labeled.
4. Ensure that all employees under their supervision attend all required Hazard Communication training, understanding how to access the Database.
5. Develop operating procedures for all tasks involving hazardous chemicals, and ensure that all personnel use required personal protective equipment (PPE) and safe working methods.

D. All Employees shall:

1. Read the MSDSs and labels to become familiar with the safety precautions, chemical and physical properties, and potential health hazards of the chemicals prior to handling them. MSDSs may be found on the GSFC web site.
2. Wear prescribed personal protective equipment (PPE), follow applicable operating procedures, and exercise all necessary precautions in the safe use of hazardous chemicals.
3. Participate in scheduled hazard communication training sessions.
4. Notify the supervisor of any apparent deficiencies involving hazard communication operating practices, and report all working conditions that may cause substantial personal exposure to hazardous chemicals.

E. Safety and Environmental Branch or its designated representative has overall responsibility for monitoring this program. Specific responsibilities include the following:

1. Providing a written Hazard Communication Program that may be adopted by this organization.
2. Assisting the MSD in determining the level and content of training required to adequately inform employees of the hazards of workplace chemicals to fully comply with the Hazard Communication Program.
3. Auditing the MSD to ensure that employees are trained in accordance with the Hazard Communication Program.
4. Providing revisions of the Hazard Communication Program on an as-needed basis.
5. Providing technical support to the MSD including hazard analyses of the workplace; safety inspections and audits; and observations and reviews of work practices, procedures, personal protective equipment (PPE), and procurements.

F. Contracting Officer's Technical Representatives shall ensure that Contractors administer a Hazard Communication Program that complies with 29 CFR 1910.1200, the *Hazard Communication Standard* promulgated by the Occupational Safety and Health Administration.

V. Labeling and Other Forms of Warning

Every container of hazardous materials shall be properly labeled or tagged with the identity of the hazardous material, appropriate hazard warning including target organ effects, and name and address of the chemical manufacturer, importer, or other responsible party. Labels or tags shall be legible, written in English, and prominently displayed on the container. Pipes, ducts, and valves carrying hazardous materials shall be clearly identified.

VI. Hazardous Materials List and Inventory

A hazardous materials list for each work area is required and shall be available to all affected employees. A sample hazardous materials list is shown in Figure 2.5-1 (note that the list has been compressed in size intentionally to fit in this Safety Manual.) The supervisor shall maintain this list and review it quarterly, at a minimum.

Figure 2.5-1. Hazardous Materials List

Code/Group Submitting Inventory:

Manufacturer Name	**Product/ Chemical/ Common Name**	**Existing Quantity**	**Quantity Used throughout the year**	**Storage Cabinet (Bldg. & Room)**	**Number of containers and size**	**Solid, Liquid, or gas**

Date Hazardous Materials List Reviewed and Updated:

VII. Material Safety Data Sheet (MSDS)

1. The MSDS is a document that describes the physical and chemical properties of products, their physical and health hazards, and precautions for safe handling, storage, and use. An MSDS is required for each hazardous chemical used in the facility. Employees are not required to work with these hazardous chemicals until an MSDS is made available for their review.
2. Supervisors are responsible for ensuring that an MSDS accompanies each initial shipment of hazardous materials.
3. The MSDSs shall be kept in the GSFC Database located at http://safety1st.gsfc.nasa.gov/chem.html
4. The supervisor shall maintain the MSDS's in a notebook (or electronic copies) in an organized manner for quick review by the employee when required. The most current version of the MSDS shall be maintained (updated at least once every two years.)

VIII. Employee Training

1. All MSD employees who work with or are potentially exposed to hazardous chemicals during the normal course of work or in a foreseeable emergency shall receive hazardous chemicals information and training. This shall occur at the time of the employee's initial assignment, a change in assignment, or whenever a new hazard is introduced into the workplace. Records of the training shall be kept in the employee's performance folder.
2. Training shall include:
   - The requirements of the OSHA Hazard Communication Standard and employee rights and responsibilities.
   - Operations in the employee's work areas involving the use of hazardous chemicals
   - The location and availability of the Hazard Communication Program, the hazardous chemical inventories, and the MSDSs of the hazardous chemicals in the work areas.
   - The contents of the Hazard Communication Program, including an explanation of the labeling system and MSDSs.
   - Methods and observations that may be used to detect the presence or release of a hazardous chemical in the work area.
   - The physical and health hazards of the chemicals in the work area.
   - The measures employees can take to protect themselves from these hazards, such as safe procedures, emergency actions, and appropriate personal protective equipment (PPE).

2.5.2 Acronyms/Definitions

1. Asphyxiant—A substance, which can displace the oxygen in an area.
2. Bonding—Eliminating a difference in static electric charge potential between two or more objects.
3. Chemical—Any element, compound, or mixture of elements and/or compounds. Includes treated woods, metals, etc.
4. Class I—A liquid having a flash point below 100 °F (37.8 °C) and having a vapor pressure less than or equal to 40 psia (276 kpa).
5. Class II—A liquid having a flash point at or above 100 °F (37.8 °C) and below 140 °F (60 °C).
6. Class III—A liquid having a flash point at or above 140 °F (60 °C).
7. Combustible liquid—Any liquid having a flash point at or above 100 °F (37.8 °C) (Class II and III), but below 200 °F (93 °C).
8. Cryogenic liquid—A liquid with a normal boiling point below -238 °F (-150 °C).
9. Flammable aerosol—An aerosol that when tested yields a flame projection exceeding 18 inches (46 cm) at full valve opening, or a flashback at any degree of valve opening.
10. Flammable gas—A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13% or less by volume, or forms a range of flammable mixtures with air greater than 12% by volume, regardless of the lower limit.
11. Flammable liquid—Any liquid having a flash point below 100 °F (37.8 °C) (Class I), except any mixture having components with flash points of 100 °F (37.8 °C) or higher, the total of which make up 99 % or more of the total volume of the mixture.
12. Flammable solid—A solid other than a blasting agent or explosive that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard.
13. Flash point—The minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite.
14. Grounding—Eliminate a potential difference between an object and the ground (earth).
15. Groups—This term shall include government divisions, other centers, contractors, and subcontractors.
16. Hazardous material/chemical—A chemical, which is a physical or health hazard.
17. Health hazard—Based on statistical evidence that acute (normally short term exposure and duration) or chronic (long term exposure and long duration) health effects may occur in exposed employees. This includes chemicals which are carcinogens, toxins, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes.

18. Immediate use—The hazardous chemical will be under the control of and used only by the person who transfers if from a labeled container and only within the work shift in which it is transferred.
19. National Electrical Code (NEC)—The most widely adopted set of electrical safety requirements, used for regulatory purposes in the interest of life and property protection.
20. Permissible Exposure Limit (PEL)—The OSHA term for the time weighted average concentration, which must not be exceeded for a normal 8-hour workday and a 40-hour workweek.
21. Physical hazard—Evidence that a chemical is a combustible liquid, compressed gas, explosive, flammable, organic peroxide, pyrophoric, reactive, or water-reactive.
22. Pyrophoric—A chemical that will ignite spontaneously in air at a temperature of 130 °F (54.5 °C) or below.
23. Reactive—A chemical which will vigorously polymerize, decompose, condense, or will be come self-reactive under conditions of shock, pressure or temperature.
24. Satellite Accumulation Point—A site in the immediate area of waste generation, which is under the control of the employees in the area. No discrete site can accumulate more than 55 gallons (208 liters) of hazardous waste or one quart (0.95 liter) of acute hazardous waste.
25. Threshold Limit Value (TLV) or Threshold Limit Value-Time-Weighted Average (TLV-TWA)—The time weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. These are recommended levels established by the American Conference of Governmental Industrial Hygienists (ACGIH).
26. Threshold Limit Value-Ceiling (TLV-C)—The concentration that should not be exceeded during any part of the working exposure.
27. Threshold Limit Value – Short-Term Exposure Limit (TLV-STEL)—The concentration to which workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded.
28. Toxins—Poisons.
29. Water-reactive—A chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

2.5.3 General

Exposure to hazardous materials must be eliminated or reduced to the greatest extent possible. The purpose of this section is to ensure all employees are informed as to the chemical hazard they may be exposed to in the workplace under normal conditions or in a foreseeable emergency. To ensure that employees are not exposed to hazardous materials/chemicals, employees must be aware of and use the MSDSs to determine both

health and physical hazards associated with the materials. Part of employee awareness is training in chemical detection and procedures to follow to prevent exposure.

2.5.4 Design/Operational Requirements

1. The S&EB must approve all hazardous materials/chemicals brought onto GSFC prior to their arrival. This applies to government, contractor, and subcontractor work. When a hazardous material purchase is being made, an "Initiator's Safety Checklist for Procurements," the Purchase Request/Order, and the material's MSDS must be routed to the S&EB for approval.
2. MSDSs must be entered into the GSFC Database for all hazardous chemicals brought into the MSD facility.
3. All outside organizations using hazardous chemicals in the MSD facility shall develop their own written hazard communication program. This shall be supplied to the Branch Office. MSD shall use this section of the Manual as their program. OSHA 1910.1200 requires each supplier, manufacturer, or user of hazardous materials to have a hazard communication program. This program consists of evaluating the hazards of the material used in the work place, having a written program, having MSDSs available for all hazardous materials, training employees in their rights to know what they are being exposed to, and labeling containers.
4. All MSDSs shall be maintained on the GSFC Database, even those used temporarily.
5. Hazardous materials shall always be properly stored at the end of each shift. Flammables must be stored in Flammable Storage cabinets and acids in Acid Storage cabinets. Never mix incompatible materials, like flammables and acids. Do not store acids near bases, since the heat of reaction between the two can be intense enough to ignite flammable and combustible materials. Always have leaky or damaged containers removed and disposed of immediately.
6. Whenever chemicals can be splashed on the skin or in the eyes, PPE shall be worn and an emergency shower and/or eyewash stations shall be available. Showers and eyewash stations shall be tested at least bi-weekly.
7. Flammable and combustible liquid requirements are:
   - Keep all heat sources away from flammable and combustible materials.
   - Control of vapors is the primary means of controlling the fire risk. Ventilation is considered adequate if it is sufficient to prevent accumulation of significant quantities of vapor-air mixture in concentrations over 10% of the Lower Flammable Limit (LFL).
   - If being used in locations where the concentrations of flammable vapors may be greater than 10% of the LFL, equipment must be rated for use in hazardous locations, meeting NEC, Article 500. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class II locations are those that are hazardous because of the presence of combustible dust. Each Class has associated Divisions, which further define types of concentrations.
   - Do not use or store flammable and combustible liquids near strong sources of radio frequency (RF) radiation.

- Do not use more than one gallon of flammable liquids on the job at a time.
- When transferring flammable liquids, especially Class I liquids, from one metallic container to another, provide a means of bonding between the two conductive containers prior to pouring. Additionally, these containers must be grounded. Static charges can build up due to pouring, pumping, mixing, filtering, or agitating flammable liquids. Bonding and grounding systems should be inspected prior to each use for broken wires, corrosion or other damage, and should be inspected annually for electrical continuity.

8. Oxidizers, peroxides, and organic peroxides:
   - Most peroxides are sensitive to heat and/or shock.
   - Keep oxidizers, peroxides, and organic peroxides away from other chemicals.
   - Do not allow peroxides to freeze. This increases their sensitivity to shock.
   - Avoid contact with metals. Metals react, helping the release of oxygen.
9. Pyrophoric materials must be handled with extreme care. Refer to the appropriate MSDS for detailed handling requirements. Operations involving pyrophorics must be designated as hazardous and must have detailed procedures approved by S&EB.
10. The use of toxic materials or materials which present health hazards should be limited. When they are used, adequate ventilation must be provided and the exposure limits described in the *ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*, and 1910.1000, *Air Contaminants* must be followed. If in doubt as to how much exposure employees may be subjected to, area or personal monitoring is required.
11. Fume hoods should be considered as a backup safety device to contain and exhaust toxic, offensive, or flammable materials. Hoods should be evaluated prior to use and annually thereafter by Industrial Hygiene to verify adequate airflow. When used, front closures must be closed as much as possible to improve performance.
12. Extremely hazardous materials, or containers, which have contained extremely hazardous material, such as hydrazine, shall not be brought into the MSD facility.
13. Carbon tetrachloride is not authorized for use, except in minute quantities as approved by the Branch Head and S&EB.
14. Asphyxiants shall not be used in enclosed areas or confined spaces unless a calibrated oxygen meter is used to verify that the oxygen levels in the ambient air are a minimum of 19.5% when personnel are present.
15. Hazards and requirements for cryogenic agents are as follows:
    - Personnel involved in cryogenic operations must have specific training in the hazards and requirements for working with this material.
    - Extreme cold is one of the most obvious hazards when dealing with cryogenics. Their cold “boil-off” vapor can rapidly freeze human tissue, and can cause many common materials such as carbon steel, plastics, and rubber to become brittle or even fracture

under stress. Cryogenic liquids in containers and piping having temperatures at or below the boiling point of liquefied air (-318 °F, -195 °C) can actually condense the surrounding air to a liquid. Liquid oxygen is an oxidizing agent.

- Cryogenic liquids spilled on exposed skin or eye tissue can cause frostbite. Always rope off and stand clear of boiling or splashing liquid and its vapors unless properly attired. Personnel involved in cryogenic operations must wear loose fitting, dry cryogenic or leather gloves, trousers which cover the top of the feet worn outside boots or work shoes, face shield, and long sleeves.
- Cryogens produce large volumes of gas when they vaporize. For example, one volume of liquid nitrogen at atmospheric pressure vaporizes to 694 volumes of nitrogen gas at 68 °F (20 °C). This can produce enormous pressures when the vessel is sealed. Cryogenic containers must be protected with pressure relief devices (see Section 2.3.1).
- Most cryogenic materials are odorless, colorless, and tasteless when vaporized to the gaseous state. Often those found in the MSD facility are also asphyxiants.
- When a warm container is filled or when warm objects are inserted into a cryogenic liquid, boiling and splashing always occur. Perform these operations slowly to minimize boiling and splashing.
- Never allow any unprotected part of the body to contact uninsulated pipes or vessels containing cryogenic fluids. Extremely cold material may stick quickly and tear the flesh when you attempt to withdraw it.
- Use tongs to withdraw objects immersed in a cryogenic liquid.
- Components used in cryogenic systems must be designed and approved for such use. For example: valves that have longer stems to allow for application of insulation and seals are compatible with extreme cold. Carbon steel becomes brittle at low temperatures and may easily fracture when stressed.
- Dispose of cryogenic liquids (nitrogen or helium) only in well-ventilated areas.

16. Emergency treatment for cold-contact burns:

- Call the Emergency Console, 911.
- Remove any clothing that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result.
- As soon as is practical, immerse the affected part in warm water (not less than 105 °F, 41 °C, or more than 115 °F, 46°C). Never use dry heat. The victim should be in a warm room, if possible.
- If the exposure has been massive and the general body temperature is depressed, the patient should be totally immersed in a warm-water bath. Supportive treatment for shock should be provided.
- Frozen tissues are painless and appear waxy and yellow. They will become swollen, painful, and prone to infection when thawed. Do not rewarm rapidly. Thawing may

require 15 to 60 minutes. For light skinned people, thawing should continue until the pale blue tint of the skin turns pink or red. For darker skinned people, assess frostbite by the swelling and blistering of the skin. Reduction of swelling indicates alleviation of frostbite.

- If the frozen part of the body thaws before the doctor arrives, cover the area with dry, sterile dressings and a large, bulky protective covering.
- Alcoholic beverages and smoking decrease blood flow to the frozen tissues and should be prohibited. Warm drink and food may be administered.
- As with any injury or illness, monitor vital signs.

17. Corrosives are capable of destroying living tissue and have a destructive effect on other substances, particularly on combustible materials; this effect can result in a fire or explosion. Adequate ventilation must be provided, as well as goggles and face shield, gloves, and an apron. Corrosive solids are activated by water. Small amounts of water will create a highly concentrated liquid corrosive.
18. Ammonia handling:
    - Physical Properties:
        a) At ambient conditions, ammonia is a colorless gas with a sharp, pungent odor. It is soluble in water, alcohol, and many other solvents.
        b) Anhydrous (having no water) ammonia is shipped as a liquefied gas under its own vapor pressure.
        c) Although ammonia is lighter than air, the vapors from a leak initially hug the ground until it thermally stabilizes. At that point, it rises and mixes slowly.
        d) Ammonia has a flammability limit between 16 (160,000 ppm) and 26.8% by volume with air. An ammonia fire is difficult to extinguish because of the large amount of water required to control it. A water spray/fog is effective in reducing the concentration of ammonia due to its high solubility. The auto ignition temperature is 651°C. The probability of an ammonia fire is infinitesimal. In order to ignite, the ammonia would have to leak to the atmosphere, which would expose it to oxygen. Then the gas would have to be exposed to an ignition source while in a critical concentration. This concentration can only occur in a small area near the leak.
        e) In the anhydrous form, ammonia is highly reactive. Ammonia corrodes copper, tin, zinc, and alloys containing these metals. It is compatible with aluminum and stainless steel. Ethylene propylene (EP) is recommended for O-rings when required.
    - Physiological Effects:

      Liquid ammonia produces severe burns on contact due to its caustic nature and from freezing during evaporation. Gaseous ammonia is a strong irritant and can cause damage to the eyes and respiratory tract.

        a) Exposure limit is 35 ppm for 5 minutes without protection. Safety requires that levels be kept below 25 ppm for workers exposed for a normal workday of 8 hours.

b) Most people can begin detecting ammonia at 5 ppm. 20 ppm is easily noticeable and 100 ppm is strong.

c) At 400–700 ppm, symptoms include nose, throat, and eye irritation. The (immediately Dangerous to Life and Health (IDLH) level is 500 ppm.

d) At 2,000–3,000 ppm, symptoms include convulsive coughing and serious eye irritation. May be fatal after short exposures.

e) Above 5,000 ppm, symptoms include respiratory spasm and rapid asphyxia, and these are fatal.

f) Ammonia is classified as a toxic gas; however, the odor is perceptible at very low levels, and the acute discomfort that it causes will warn personnel of its presence. This will allow personnel to escape from small leaks or spills.

- Handling Procedure:

  During handling operations of test items containing ammonia, the following rules shall be adhered to:

  a) All personnel involved with the operation shall be familiar with this document.

  b) The buddy system shall be implemented at all times.

  c) Personnel working in confining areas, such as vacuum chambers, shall wear chemical goggles.

  d) Eyewash stations shall be readily accessible and tested/verified operational.

  e) Personnel shall be briefed as to the location and operation of building exhaust fans.

- Ammonia Leak Emergency Procedures:

  Always remain calm in an emergency. The following must be adhered to:

  a) Activate the building fire alarm and evacuate all personnel from the building.

  b) Activate the building emergency exhaust fans by pressing the start button at any location.

  c) Go to the designated evacuation location (parking lots at the front and rear of the buildings) and meet with the GSFC Emergency Response Team (GERT). Do not re-enter until told to do so by GERT.

- First Aid:

  If unsure of first aid measures to take, immediately contact the Emergency Console at 112.

  a) Eye or Skin Exposure—Flush ammonia-exposed areas with large quantities of water for a minimum of 15 minutes. Affected clothing must be removed immediately. Wash exposed skin areas thoroughly with soap and water.

  b) Inhalation—Victim must be taken to an uncontaminated area. Emergency personnel should avoid self exposure to ammonia. Call the Emergency Console, 112, if

breathing is difficult, so that oxygen can be administered. If the victim has stopped breathing, administer rescue breathing. If no pulse is detected, administer CPR.

19. Large quantities of flammable chemicals, such as drum-sized containers used in Buildings 5, 7, 10, 15, and 29, shall be stored in the provided drum storage buildings. These are Building 85 (located north of Building 29) and Building 93 (located east of Building 5).
20. Hazardous waste must never be poured down the drain or disposed of in trashcans. Chemicals scheduled for disposal shall be placed in properly marked containers, separated by class of waste (health hazard, corrosive, flammable). Never accumulate more than 55 gallons (208 liters) of waste at any Satellite Accumulation Point. Only one quart (0.95 liter) of acute hazardous waste (e.g., cyanides) shall be assimilated at a Satellite Accumulation Point. For removal contact the GSFC Hazardous Waste Environmental Specialist (6-9233). Prepare a Hazardous Waste Disposal Inventory Form, NASA WI-1550, and submit it to the waste disposal personnel. Copies of the MSDSs shall be readily available.
21. Spill control – In the event of a spill, always review the MSDS prior to attempting any cleanup. Personnel shall never attempt to cleanup a spill of a material they have not worked extensively with. If the material is unknown or not familiar to the employee, evacuate the area. Secure the area well enough to keep unauthorized personnel away from the spill. Only attempt cleanup of any spill if specifically trained to do so, training is current and protective equipment is available. Contact the Emergency Console at 911. A contractor specifically trained to handle spills shall respond.

2.5.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Safety Support Contractor (301) 286-1035

2.5.6 Reference Documents Unique to this Section

29 CFR 1910.1200, *Hazard Communication Standard*

29 CFR 1910.1450, *OSHA Laboratory Standard*

29 CFR OSHA, *Subpart Z: Toxic and Hazardous Substances*

NHS/IH-1845.3, *NASA Health Standard on Hazard Communication*

United States Department of Agriculture, Hazard Communication: A Program Guide for Federal Agencies. August 1987

Fed-Std-313, *Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities*

GPG 1700.2, *GSFC Chemical Hygiene Program*

NFPA 70, *The National Electrical Code*

2.6 Non-Ionizing Radiation Systems

2.6.1 Scope

This section describes the requirements for the safe use of non-ionizing radiation systems brought into or used within MSD facilities.

2.6.2 Acronyms/Definitions

1. Carcinogenic—Capable of causing cancer in a biological system.
2. Electromagnetic Radiation—The flow of energy consisting of orthogonally vibrating electric and magnetic fields lying transverse to the direction of propagation. X-rays, ultraviolet, visible, infrared, and radio waves occupy various portions of the electromagnetic spectrum and differ only in their frequency and wavelength.
3. Infrared Radiation (IR)—Invisible electromagnetic radiation with wave-lengths which lie within the range of 0.70 to 1,000 μm. These wave-lengths are often broken up into regions: IR-A(0.7-1.4 μm), IR-B (1.4-3.0 μm), and IR-C (3.0-1,000 μm).
4. Laser—An acronym for Light Amplification by Stimulated Emission of Radiation. A laser is a cavity with mirrors at the ends filled with material such as crystal, glass, liquid, gas, or dye. It is a device which produces an intense beam of light with the unique properties of coherency, collimation, and monochromaticity.
5. Point Source—A source of radiation whose dimensions are small enough compared with the distance between source and receptor for them to be neglected in calculations.
6. Pulsed Laser—A laser which delivers its energy in the form of a single pulse or a train of pulses. In this Safety Manual, the duration of a pulse is less than or equal to 0.25 seconds.
7. Radio-Frequency (RF) Radiation—Invisible radiation most commonly produced by radio or television transmitters and radar equipment. When arcing or "sparking" occurs, it is projected by a variety of other electrical equipment in a random form perceptible through ordinary radio or television receivers as "static." It is also deliberately produced for therapeutic effects in limited areas by the diathermy devices used in doctors' offices.
8. Ultraviolet (UV) Radiation—Electromagnetic radiation with wavelengths between soft x-rays and visible violet light, often broken down into UV-A (315-400 nm), UV-B (280-315 nm), and UV-C (100-280 nm).
9. Visible Radiation (Light)—Electromagnetic radiation, which can be detected by the human eye. It is commonly used to describe wavelengths, which are in the range of 0.4 to 0.7 μm.

2.6.3 General

Forms of non-ionizing radiation include light—both visible and invisible—infrared (radiant heat) and ultraviolet rays, as well as the whole spectrum of radio waves. At their ordinary levels, these forms of radiation are not usually harmful and are often beneficial. In sufficient quantities, however, they can produce harmful effects, ranging from sunburn and skin cancer to blindness or other injury.

2.6.4 Operational Requirements

1. Use of any non-ionizing radiation source requires completion of GSFC Form 23-6RF, GSFC Request for Radiation Safety Committee Action RF/Microwave Source Questionnaire and 23-28RF, Request for Radiation Safety Committee Action RF/Microwave Source Questionnaire or 23-35UL, Contractor Laser User Eye Exam Verification, 23-28L, Request for Radiation Safety Committee Action – Laser Radiation Source Questionnaire, and 23-6L, GSFC Request for Radiation Safety Committee Action Laser Radiation Source Personnel Approval. The forms must be submitted to the GSFC Radiation Protection Officer (RPO) for approval at least two weeks before the source is to be brought onto the Center. In the case of ultraviolet and high intensity lights (such as those used for NDT work), no form is required; however, the user shall verbally notify the RPO that such lights are being used. Wear the eye protection and/or protective clothing prescribed for any equipment you are operating. Form 23-6I determines adequate training.
2. Post proper warning signs in any areas in which dangerous radiation exists, and if necessary, erect barriers and exercise traffic control to prevent injury to other persons who enter the area.
3. Consult individual device manuals for hazard prevention.
4. Although infrared radiation is not actually heat, it produces heat in objects that it strikes. In sufficient intensity, it may ignite flammable materials or severely burn living tissue. Serious eye damage may result from looking directly at a source of infrared light before any symptoms become apparent. Two basic rules should be observed:
   - Do not expose flammables or explosives to concentrated infrared rays.
   - Do not look directly at a source of concentrated infrared light without adequate eye protection.

   NOTE: Glasses that protect against ultraviolet radiation do not always protect against infrared. Eye protection must be rated for the level of infrared protection you may be exposed to.
5. Radio-Frequency (RF) radiation's most common biological effect is a rise in body temperature, usually noticeable before serious damage occurs. However, it can cause severe burns in the case of any bodily contact with metal objects such as rings, belt buckles, etc. In sufficient concentrations (usually only in close proximity to a powerful transmitter), it may cause serious permanent damage to the eyes. In such concentrations, it may also cause temporary damage to the male reproductive organs, resulting in temporary sterility (but not impotence) that later disappears.
   - Random RF radiation from devices such as arc welders is not directed in a concentrated beam and is rapidly dissipated, although such equipment presents other hazards that will be described later in Section 4.18.
   - Besides its biological effect, RF radiation creates another hazard: it may ignite or detonate explosive devices at a considerable distance from its source. This hazard is discussed in Section 2.2.

6. Lasers:
   - Avoid looking directly into any laser beam or its reflections.
   - Remove all unnecessary specular (shiny) reflecting surfaces from the area. Avoid looking at reflections in the laser mirrors, shiny spherical objects such as doorknobs, screw heads, window panes, watch crystals, rings, tools, jewelry, or the mirrors and shiny surfaces of laboratory equipment.
   - Lasers shall be used only in controlled areas. Post the area with appropriate signs to alert persons passing by the area that a potential hazard exists.
   - When the laser system is not in use, ensure that it is inaccessible to unauthorized personnel.
   - Immediately report any accident to the medical facility, especially if an eye is involved.
   - Before high-power, advanced-type (Class 3b and 4) laser systems are used, the user shall obtain prior approval of the GSFC Radiation Safety Committee. Safety precautions should include at least the following:
     a) Never look directly into the laser beam or pump source during firing or at the laser's specular reflection.
     b) Never permit any part of the body to intercept the laser beam or its reflection.
     c) When possible, physically isolate the laser firing area from the control panel. Post the control and firing area with adequate signs warning of the hazard, carefully control personnel access, and recommend visible and/or audible signals for the area.
     d) Illuminate all areas used for laser firing with high-level lighting that will constrict the pupil of the eye to reduce the probability of retinal damage.
     e) Aim the beam indirectly and never look into the primary beam. Adopt a count-down system with eyes completely closed for use when high-power pulsed lasers are energized.
     f) Use a nonreflective, fire-resistant surface as a target background. Paint or coat the surrounding area to absorb any scattered or reflected radiation. Ensure that the laser beam is directed so it cannot strike vessels that contain combustible materials.
     g) Clear the area along all parts of the anticipated path of the laser beams of personnel, reflective objects, and flammable materials.
     h) Remember that materials that are bombarded and vaporized by the incident beam can result in atmospheric contamination. Toxic materials from such vapors or fumes include lead, ozone, carbon monoxide, cadmium, and mercury.
     i) Take positive action to prevent accidental energizing of pulsed lasers. Turn the power off and discharge the capacitors before making any repairs or adjustments that may expose the operator or others to the incident beam or to electrical shock.

j) Do not rely on safety glass to view the direct laser beam. If safety goggles are to be furnished, ensure that they protect against the specific energy and wavelength of the beam under consideration.

7. Ultraviolet Radiation:

- Ultraviolet radiation is an invisible form of light, present in ordinary sunlight. In greater concentrations, it can burn the eyes and skin. All solar simulators, blacklights, and some optical testing facilities in use in MSD produce such concentrations. In particular, it can cause severe skin burns and eye damage up to and including total and permanent blindness.
- Ultraviolet radiation is not apparent to the ordinary human senses except through symptoms that appear only after the damage has been done. Fortunately, ordinary clothing and glass quartz used in solar simulators or even window glass eliminate the worst effects of normal concentrations.
- When any black light is brought into the MDS a letter must be provided to S&EB at least 30 days prior to bring onto GSFC indicating: 1) manufacturers specifications and warnings; 2) where the light will be used; 3) the designated light custodian (name and project); and 4) how it will be used.
- The basic safety precautions to be observed in the presence of ultraviolet radiation are as follows:

  a) Do not operate, or remain in the vicinity of, devices that produce ultraviolet radiation without wearing prescribed eye and skin protection.

  b) Do not expose unclothed portions of your body to ultraviolet radiation devices.

  c) Post appropriate warning signs in any area in which ultraviolet radiation is present; and, if necessary, exercise traffic control to ensure that other personnel who enter the area will not be exposed to dangerous radiation.

  d) If you are not involved in operations involving ultraviolet radiation but must enter such an area, obey all warning signs and instructions of operating personnel.

  e) Do not use glass as transmitting windows for solar simulators where energy collection can cause glass failure.

8. Solar Simulation:

- A series of powerful lamps, designed to duplicate the spectrum of the sun as closely as possible, produce simulated solar radiation in intensity far greater than that of ordinary sunlight which reaches Earth after filtration through the atmosphere. This light consists of infrared, ultraviolet, and visible light. Direct exposure of unprotected personnel to simulated solar radiation can cause severe burns and eye damage. Ozone is a byproduct. Any person who must occasionally be exposed to such radiation must wear prescribed eye protection or masks with suitable radiation-filtering lenses, as well as hoods and other protective clothing to preclude burns. This equipment may also produce some ionizing radiation.

- Solar simulation lamps have an explosion hazard.
  a) Wear specially designed heavy insulated gloves, protective clothing, safety glasses and face shields when changing simulation lamps.
  b) Because of their high internal pressure, place simulation lamps in protective housings immediately during changing and storage.
  c) Permit only authorized and qualified personnel to operate and maintain solar-simulation equipment. Post the area with warning signs and clear non-essential personnel from the area when performing lamp changeout.
  d) Ensure all viewing ports on solar simulators are quartz and are protected with a polycarbonate (Lexan) to protect against an implosion hazard.
  e) Do not use glass as transmission ports for solar simulators where energy collection can cause glass failure.

9. Light:

- Light can cause not only severe skin burns but also serious and permanent damage to the eyes. Even "natural sunlight," reinforced by reflections from wide expanses of snow, can cause the "snow blindness" familiar in high altitudes; and all of us are familiar with the "blinding" effects that result from looking at the sun or from the sudden appearance of headlights on a dark highway. Although the light of various devices used in MSD, including ultraviolet and welding devices, is sufficiently perceptible to cause personnel to avoid serious danger, it can cause damage and should not be underrated. Any source of light that is more intense than those encountered in everyday life should be treated with respect. The general precautions specified previously for infrared and ultraviolet light are usually more than adequate to avoid danger from visible light.

2.6.5 GSFC Contacts

S&EB: (301) 286-2281
Radiation Protection Officer (RPO): (301) 286-4693
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.6.6 Reference Documents Unique to this Section

GPG 1860.2, *Radiation Safety Handbook—Radio Frequency*

GPG 1860.3, *Radiation Safety—Laser*

GPG 1860.4, *Radiation Safety—Ultraviolet and High Intensity Light Radiation*

ANSI C95.1, *American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields*

ANSI Z136.1, *American Standard for Safe Use of Lasers*

ASNT 018-82, *Radiation Protection Section 18, The Non-Destructive Testing Handbook on Radiography and Radiation Heating*

EIA LEB1-70, *Safety Classification of Laser Equipment and Installations*

OSHA 29CFR 1910.96, *Radiation Safety*

OSHA 29CFR 1910.97, *Non-Ionizing Radiation*

OSHA Instruction PUB 8-1.7, *Guidelines for Laser Safety and Hazard Assessment*

2.7 Ionizing Radiation Systems

2.7.1 Scope

This section describes the requirements for the safe use of ionizing radiation sources brought into or used within the MSD facilities.

2.7.2 Acronyms/Definitions

1. Background radiation—Ambient ionizing radiation to which individuals are always exposed.
2. Contamination (radiation)—A condition in which radioactive material has spread to places where it may harm persons, spoil experiments, or make products or equipment unsafe or unsuitable for some specific use.
3. Dosimeter—Any instrument which integrates the dose rate with time.
4. Film badge—A dosimeter consisting of an appropriately packaged nuclear emulsion film for detecting the amount of radiation personnel have received. Film badges are usually dental-size x-ray film worn on the person.
5. Monitoring—Periodic or continuous check on the amount of ionizing radiation contamination present in the environment. This check is a measure for health protection.
6. Radiation, ionizing—Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter or air.
7. Radiation, nuclear—Radiation emitted by the nucleus, which includes gamma rays, beta and alpha particles and sometimes neutrons and protons. It does not include x-rays.
8. Radiation-producing equipment—Any device, machine, or equipment capable of producing radiation (e.g., x-ray tubes, accelerators, cathode-ray tubes, klystrons, thyratrons, magnetrons, resonance transformers, and electrostatic precipitators.)
9. Radiation source—Any radioactive material or radiation-producing equipment.

2.7.3 General

- Ionizing radiation is produced by certain naturally occurring and man-made elements (e.g., uranium, plutonium, einsteinium, lawrencium and radium, etc.); in lower intensities by some isotopes of a great variety of more common elements; and by a number of man-made devices, including x-ray apparatus and particle accelerators.
- In sufficient concentrations, ionizing radiation can cause serious damage to living tissue. Such damage may be genetic (affecting future generations), as well as somatic (up to and including death). The action of ionizing radiation is particularly insidious because it is not perceptible by the ordinary human senses except through symptoms that appear after the damage has been done.

2.7.4 Operational Requirements

1. The RPO must approve all uses of ionizing radiation. For radiation sources forms 23-6I, GSFC Request for Radiation Safety Committee Action Ionizing Radiation Source Use

Approval, and 23-28I, GSFC Request for Radiation Safety Committee Action Ionizing Radiation Source Questionnaire, and 23-35IP, GSFC Request for Radiation Safety Committee Action Ionizing Radiation Source Personnel Approval and for devices forms 23-6ID, GSFC Request for Radiation Safety Committee Action Ionizing Radiation Producing Device Approval and 23-28ID, GSFC Request for Radiation Safety Committee Action Ionizing Radiation Producing Device Approval must be submitted at least two weeks prior to the arrival of the source.

2. Personnel using ionizing radiation shall take a basic course and a refresher course on this topic every two years. The training is provided by the RPO. Reference GHB 1860.1 contains detailed safety rules and procedures for operations in this field. All personnel whose duties involve exposure to ionizing radiation should become familiar with its provisions. They will not be repeated here except for the following, which deserve special emphasis:
   - The location of ionizing radiation sources shall never be changed/moved without notifying the RPO.
   - Responsibility for the use, storage, and handling of any source of ionizing radiation must be assigned to an RPO-approved custodian, as specified in GHB 1860.1.
   - All wipe tests (arrival, periodic, and after environmental tests) shall be scheduled with the S&EB as far in advance as practical. Sources shall not be unpacked without S&EB presence. The procedure shall be as follows:
     a) Call the S&EB to establish tentative schedules for wipe tests. Reschedule when major changes occur.
     b) When the wipe test is ready to be performed, make arrangements with the S&EB one day before the wipe test.
   - All ionizing radiation areas must be posted with warning signs as provided in GHB 1860.1. When appropriate, traffic control should be exercised to prevent accidental exposure of personnel not involved in the operation in progress.
   - All personnel occupationally exposed to ionizing radiation shall be provided with film badges, dosimeters, or other personnel monitoring equipment, as prescribed by GHB 1860.1.
3. Procedures shall be prepared for each device that produces ionization. Procedures shall be approved by the RPO and posted in the vicinity of the device in question. Personnel involved in the operation of each device shall be required to read the instructions and indicate by initial that they have done so.

2.7.5 GSFC Contacts

S&EB: (301) 286-2281
RPO: (301) 286-4693
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.7.6 Reference Documents Unique to this Section

GPG 1860.1, *Ionizing Radiation Protection*

Title 10 CFR 19, *Notices, Instructions and Reports to Workers: Inspections*

Title 10 CFR 20, *Standards for Protection Against Radiation*

2.8 Electrical Systems and Equipment

2.8.1 Scope

This section covers various electrical systems and equipment containing inherent electrical hazards that are found throughout the MSD facilities.

2.8.2 Acronyms and Definitions

1. Ground (GND)—Stable voltage reference of 0.0V against which all other voltages are referenced. Also referred to as earth, circuit, or signal ground.
2. Ground fault circuit interrupter (GFCI)—Device that instantaneously detects when a ground fault has occurred, and automatically disables the power.
3. Hazardous Voltage—Typically defined as 50 volts and above with respect to ground. This must be treated as an approximation because voltage alone does not injure; currents as low as 0.1amp can injure. Systems carrying large current (tens or hundreds of amps) can operate at voltages lower than 50 volts.

2.8.3 General

All electrical equipment should be operated and serviced only by personnel with adequate knowledge and qualifications derived from experience and training. Personnel who are qualified on some equipment may not be qualified on others.

2.8.4 Who is Qualified?

Qualified persons are those who have been trained in avoiding the electrical hazards of working on or near exposed energized components. They must possess the skills, techniques, and knowledge necessary to:

1. Distinguish exposed live parts from other components of electric equipment.
2. Determine the nominal voltage of exposed live components.
3. Know the proper clearance distances to be observed for the voltage involved.
4. If direct contact or contact by means of tools or material is required, must be capable of working safely on energized circuits, and shall be familiar with the proper personal protective equipment (PPE), insulating and shielding materials, and insulated tools.

2.8.5 Basics

The remainder of this section will address safety considerations for Qualified Persons involved in repairing and maintaining electrical equipment.

1. Always use applicable lockout/tagout procedures (Section 3.8). Check all electrical services with a calibrated meter to verify that the electrical service is positively secured. Always check for additional or secondary circuit breakers and power sources, which need to be locked/tagged out for the specific piece of equipment.
2. Obtain all safety equipment required for the job (glasses, goggles, shoes, gloves, meters, etc.) before working on any equipment or electrical service.

3. Check calibration dates to ensure that equipment has been inspected and is in good working order before working on a job.
4. Check plugs and cords for wear, damage, or abrasion. Do not use a tool if it is damaged in any way.
5. Verify that the outer cabinets of custom GSE are at ground potential, using calibrated meters to ensure safety.
6. When operating or repairing any electrical equipment, ensure that you are not standing on wet concrete or earth unless you have rubber soled shoes, boots, or other insulation, such as a rubber mat. Use a GFIC wherever possible.
7. Ensure that you are protected when near metal piping ducts or metal structural members. Observe minimum clearance distances around energized components (see OSHA 1910.303). Uninsulated conditions could cause a grounding situation and result in severe electrical shock.
8. Do not attempt to repair or adjust electrical equipment before disconnecting it from its power source. If power must be left on for a specified operation of this type, the area supervisor shall perform a hazard review and incorporate special safety procedures for the operation before the job is started. The buddy system is mandatory for this operation. Use appropriate warning signs, barriers, and traffic control measures.
9. Do not attempt to bypass safety interlocks.
10. When the manufacturer has provided a grounding connection, use it.
11. When working on overhead electrical circuits, use wooden or fiberglass ladders rather than aluminum or metal ones.
12. Ensure that proper tags and warning signs are attached to all equipment that is left unattended while in operation or undergoing repair.
13. Ensure that all other equipment that requires special warnings is appropriately tagged to warn personnel of the hazard.
14. Be familiar with first aid and CPR techniques for shock and burns.
15. Do not attempt maintenance work on any electrical equipment unless you are qualified and have obtained the permission of your immediate supervisor for the work in question.
16. If you feel yourself to be unqualified to perform work for any reason (lack of knowledge, lack of training, poor information available on the system, feeling sick, etc.) report the problem to your supervisor.

2.8.6 High-Voltage Equipment (600 Volts and Greater)

The guidelines provided in Section 2.8.5 apply to all high-voltage equipment. In addition, the following should be observed when performing maintenance on specific equipment:

1. Special Precautions:
   - All work on high-voltage equipment shall be conducted using the buddy system and written procedures. The buddy will be a qualified safety observer whose primary responsibilities are to do the following:
     a) Enforce safety procedures and summon help in the event of an emergency.
     b) Know and be capable of using emergency first aid treatment, including cardiopulmonary resuscitation (CPR).
     c) Permit no one to approach the equipment without first giving positive warning of the potential dangers.
     d) Stand where he/she can see all personnel who are working on the equipment and can easily reach the main power switch in an emergency.
     e) Immediately disconnect the power source at the first sign of an emergency or accident.
   - First aid training, including CPR, shall be provided to all safety observers.
   - Warning signs shall be installed in all areas where high voltages in excess of 600 volts are present.
   - Conspicuous signs containing precautions that apply to the particular equipment shall be installed on all high-voltage equipment. When large capacitors are used, the hazard exists even when the voltage and current are turned off.

     Personnel involved in maintaining high-voltage electrical equipment shall not wear any metal objects, such as rings, metal wrist bands, watch chains, etc., when working on the equipment.
2. Buss Bars:
   - Before performing any maintenance on a buss bar, ensure that the power is off and the circuit breaker is locked and tagged.
   - Verify that the line is de-energized both in front of and behind the buss bar, using a calibrated meter.
   - Connect a ground strap to a ground connection and to the buss bar. This will shunt voltage and current to ground if the system is accidentally re-energized.
   - Wear insulated gloves when installing or removing buss bars to prevent injury from accidental energizing of the line.
3. Circuit Breakers:
   - Before performing any maintenance on a circuit breaker, ensure that power is secured and the line side of the breaker is disconnected. The means of accomplishing the

disconnection varies with the type of circuit breaker; the manufacturer's instructions describing the procedure and precautions for the disconnection should be followed.

- The load side of the breaker should then be grounded to prevent shock from energy-storage devices in the load.

4. Generators and Motor-Generator Sets:
   - Before performing maintenance on a generator, alternator, or motor-generator set, ensure that the power is off, the circuit breaker is locked and tagged, and all electrical storage devices (isolation capacitors, saturable reactors, transformers, etc.) have been fully discharged.
   - Always keep a grounding bar in the vicinity of the generator control panel.
5. Isolation Capacitors:
   - Before performing any maintenance on an isolation capacitor, ensure that the power is off and the circuit breaker is locked and tagged.
   - With a voltmeter, ensure that the capacitor is fully discharged before performing a maintenance operation.
   - Attach a grounding strap to the ground connection and to the line and load sides of the capacitor.
6. Power Amplifiers:
   - Before performing any maintenance on a power amplifier, ensure that the power supply is off, the circuit breaker is locked and tagged, and a nylon rescue rope is available.
   - Discharge all energy-storage devices (capacitors, autotransformers, reactors, etc.) using the grounding bar that is connected to the ground side of the amplifier. Ensure that all of the energy-storage devices are completely discharged.
7. Rheostats, Power Resistors, and Rectifiers:
   - Observe applicable capacitor precautions.
   - Allow rheostats, power resistors, or rectifiers time to cool before removing or replacing them.
8. Shock Boards, Contactors, and Relays:
   - Observe applicable capacitor precautions.
   - Observe additional manufacturer's safety precautions.
9. Transformers and Autotransformers:
   - Before performing any maintenance on a high-voltage transformer or autotransformer, ensure that the power supply is off and the circuit breaker is locked and tagged. When de-energizing the incoming power autotransformer, wear heavy thick-soled rubber boots, pull the circuit breaker at the side of the transformer, lock and tag the circuit breaker, and then attach a grounding strap to a ground connection and to the load side of the

transformer. Verify that the oil fill is non-hazardous (no polychlorinated biphenyls, etc.). If the oil fill is in question, contact the S&EB for their recommendations.

- Open the vent valve and note the oil level in the transformer. Before energizing the transformer, ensure that the oil level is proper and the vent valve is shut.
- When renewing the oil in a power transformer, exercise extreme caution to prevent splashing oil on the insulators at the top of the transformer.
- Maintain "Danger" signs in all areas in which power transformers or autotransformers are located.

10. Miscellaneous High-Voltage Equipment:

- In general, when dealing with high-voltage equipment, remove the equipment from the line and discharge the line and load sides of the equipment.
- Use the manufacturer's procedures for removing, maintaining, and reinstalling the equipment.

2.8.7 Alternating-Current Equipment

Alternating-current (ac) equipment usually presents a lower level of hazard than direct-current (dc) equipment, although accidents occur more frequently with ac. However, special hazards are inherent in high-voltage ac equipment and in some ac equipment that generates energy in high-frequency forms. Special precautions given previously in the section on high voltage apply to all high-voltage ac equipment. The following additional precautions for each equipment category below should be observed during the operation and maintenance of ac equipment:

1. Motors and Alternators:

- Before disconnecting a motor from a power supply, connect a ground strap to the input leads to discharge any energy storage devices on the line.
- Do not wear loose clothing when working near moving motors or generators.
- Keep all objects away from the motor cage.
- When examining the brushes or slip rings on a motor or alternator during operation, wear insulated shoes and gloves.

2. Transformers and Amplifiers:

   This classification includes various specialty transformers, servomechanisms, specialty amplifiers, limited-power amplifiers, and operation amplifiers. Follow the manufacturer's procedures when servicing this equipment.

3. Test Equipment:

- Be thoroughly familiar with the use of test equipment before applying it to a live circuit.
- When using a voltmeter with a range selector, ensure that the proper range is being used. Failure to observe this precaution may result in destruction of the meter or injury to the operator.

4. Calibration Equipment:
   - Keep ac voltage reference sources in a standby condition when left on between tests.
   - When operating with a thermal transfer voltmeter, exercise care to prevent overloading the meter.

2.8.8 Direct-Current Equipment

The most significant hazard inherent in dc equipment is that in making or breaking a contact, an arc may result that can cause damage to eyes, depending on the position of the individual with respect to the arc. Both alternating and direct current can hold an individual when contact is made. However, the person who makes contact may be thrown rather then held, in which case the injuries sustained are less severe. In most cases, the proper safety precautions for dc equipment are the same as those for high-voltage equipment. However, the following additional precautions should be observed while servicing dc equipment:

1. Current Shunts:
   - Do not use a current shunt for any other purpose than its design (calibration, contactor heater, etc.).
   - Do not touch a current shunt during operation.
   - If the rating of a shunt is not known, do not use it.
   - Before connecting or disconnecting a current shunt, ensure that the power supply is off and all energy-storage devices on the line have been discharged.
2. Knife Switches and Fuses:
   - When making or breaking a contact with a knife switch or fuse, ensure that the contact is fast enough to prevent arcing.
   - Use a fuse puller when removing or installing fuses. Fuses should not be removed or inserted into live circuits. Always turn off the power first.
   - Do not look directly at the arcing of contact points.
   - Ensure that you are not grounded.
   - All fuse and switch boxes should be marked on the outside and inside covers to show the voltage present, rated fuse capacity, and the equipment circuit controls.
3. Motors and Generators:
   - Observe applicable ac motor precautions.
   - When examining the brushes or commutator on a motor or generator, wear safety glasses or goggles and insulated gloves, and either wear insulated shoes or stand on an insulated surface such as a rubber mat.
4. Nonquenching Contactors:
   - Observe applicable circuit breaker precautions.
   - Observe applicable fuse precautions.

- Never engage a contactor by hand.
- When a contactor trips out because of overload, reduce the load; do not shunt the overload relay or heater.

5. Regulators and Converter:
   - Before performing any maintenance on a regulator or converter, ensure that the power supply is off and the circuit breaker is locked and tagged.
   - Attach a ground strap to the line and load sides of the regulator or converter.
6. Test Equipment:
   - Observe applicable ac test equipment precautions.
7. Calibration Equipment:
   - Observe applicable current-shunt precautions given previously.
   - Exercise extreme caution when operating dc voltage and current sources. Keep these sources on "standby" when not in use.
   - When performing operations with a thermal transfer voltmeter, exercise care to prevent overloading the meter, which would result in damage to the meter and possible injury to the operator.

2.8.9 Grounding

1. Grounding of GSE and flight hardware:
   - Custom GSE shall be constructed so the hardware case is grounded to prevent electrical shock to the operators.
   - Custom GSE should have all exterior switches, pushbuttons, displays, etc. isolated from power and at ground potential along with the case.
   - Any exposed power access (such as knife switches, fuses, etc.) should be marked with appropriate hazard tags and shielded from common access.
   - Flight hardware should be constructed so the structure is at ground potential to help shield electrostatic discharge (ESD) sensitive components.
   - Personnel operating with or near such ESD sensitive hardware should wear ground straps and connect them to grounds provided near the GSE or flight hardware.

2. Working clearance around facility high-voltage equipment:

   - Working clearance of 3 feet (0.9 m) minimum must be provided between a panel, buss bar, circuit breaker panel, etc. with exposed live parts between 0 and 150 volts and any adjacent non-insulated ground (exposed concrete wall, exposed conduit, etc., which is considered to be at ground potential).
   - Working clearance of 3.5 feet (1.1 m) minimum must be provided for panels with voltages between 151 and 600 volts and exposed grounds.

     The following chart of minimum working clearances is applicable for higher voltages under varying conditions as described below:

Table 1 Minimum Working Clearances for High Voltage

Voltage to Ground	Minimum Working Clearances		
	Condition A	Condition B	Condition C
601–2,500	3 ft (0.91m)	4 ft (1.22 m)	5 ft (1.52 m)
2,501–9,000	4 ft (1.22m)	5 ft (1.52 m)	6 ft (1.83 m)
9,001–25,000	5 ft (1.52m)	6 ft (1.83 m)	9 ft (2.74 m)
25,001–75kvolt	6 ft (1.83m)	8 ft (2.44 m)	10 ft (3.05 m)
Above 75kvolt	8 ft (2.44m)	10 ft (3.05 m)	12 ft (3.66 m)

Definition of conditions A, B, and C listed above:

a) Exposed live parts on one side of the individual and no live or grounded parts on the other side of the working space; or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. (Insulated wire or insulated buss bars operating at not over 300 volts are not considered live parts.)

b) Exposed live parts on one side and grounded parts on the other side. (Concrete, brick, or fire walls will be considered grounded surfaces.)

c) Exposed live parts on both sides of the workspace not guarded as provided in (a) with the operator between.

- Overhead clearances for 601–7,500 volts must be 8.5 feet (2.59 m) minimum and 9 feet (2.74 m) for voltage ranges of 7,501–35kv.
- Overhead clearance for voltages greater than 35kv are 9 feet plus 0.37 inches (2.74 m plus 0.94 cm) per kv above 35kv.

3. Ground Fault Circuit Interrupters (GFCI):

   - Incorporate GFCI circuits in extension cords that will be used to operate powered hand tools, especially when working in a damp or enclosed area, where the operator may also contact grounded surfaces.
   - Incorporate GFCI circuits into custom GSE for each unit and especially if the unit will be used to transmit or provide power to additional pieces of equipment.

2.8.10 Custom GSE Considerations

1. All custom GSE should have common safety features in their design, including the following:
   - All equipment shall have switches to turn off power prior to installation, use, or repair. The main power switch should be clearly marked and should operate a power indicator light as well as energizing the rest of the equipment. Subsequent switches operating power to subcircuits should also be labeled, have indicator lights, and not bypass the main power switch.
   - Fuses, circuit breakers, and other protective devices are required for GSE primary circuits. Connect protective devices to the load side of the main power switch unless neutral power sensing is required for protection of equipment.
   - If three-phase power is being used, all three lines should be fused and tripped in common so that a fault in any phase will trip all three.
   - Redundant circuits should operate on fuses and switches separate from the primary circuits.
   - Interlocks are required on all GSE units provided with doors, covers, or plates, unless:
     a) Operating voltage is less than 30 volts rms or dc; or
     b) Barriers or guards are provided to allow operator adjustments without the risk of personnel contact with 30 volts or greater. These barriers should identify the voltage hazard.
   - Non-bypassable interlocks are required on the enclosure of subassemblies within major GSE units if voltage exceeds 500 volts rms or dc.
   - “Caution” signs should be clearly visible when the enclosed voltage range is between 30 and 500 volts.
   - “Danger” signs should be clearly visible when the enclosed voltage range is 500 volts or greater.
   - For monitoring high-voltage circuits, try to incorporate proportional step-down monitoring circuits, which can be measured with little hazard.
   - Connectors with different alignment pins or keyway arrangements should be used to make it impossible to incorrectly mate any external circuitry or create a hazardous condition by reversing polarity.
   - If redundant external circuits are employed, they should be accessed through separate connectors.
   - For transmission of power, male plugs shall not be the source of power, which would expose any handler to electric shock.
   - All cases, switch knobs, controls, etc. shall be at ground potential to prevent shock to the operators.

- When equipment is to be used in a hazardous atmosphere, observe NEC 500 precautions and/or NASA guidelines regarding explosion-proof design.
- When equipment is to be used in a controlled atmosphere (purged or cleanroom), observe the NEC and/or NASA guidelines regarding requirements for venting and air circulation in those atmospheres.

2.8.11 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.8.12 Reference Documents Unique to this Section

29 CFR 1910, *Subpart S, Electrical*

Institute of Electrical and Electronic Engineers (IEEE) 510-83

National Electrical Code, 1993 Edition—Articles 430, 445, 450, 455, 460, 470

2.9 Noise

2.9.1 Scope

This section covers noise and its hazards.

2.9.2 Acronyms/Definitions

1. Action Level—An exposure to an 8-hour time-weighted average of 80 decibels, measured with a sound level meter on the A-scale, slow response. The action level is the criterion for instituting noise surveys and for employee participation in a medical monitoring program for hearing conservation.
2. Administrative Control—Any procedure that limits noise exposure by control of work schedules.
3. Audiogram—A chart or table resulting from an audiometric test. An audiogram shows an individual's hearing threshold level as a function of frequency. A baseline audiogram is one against which future audiograms are compared.
4. Decibel (dB)—A unit of measurement of sound pressure level. The decibel level of a sound is related to the logarithm of the ratio of sound pressure to a reference pressure (internationally accepted for acoustics as 20 micropascals). Decibel, A-weighted (dBA) is a sound level reading made on the A-weighted network of a standard sound level meter at slow response.
5. Engineering Control—Any mechanical device, physical barrier, enclosure, or other design procedure that reduces the sound level. This does not include PPE such as ear defenders or plugs.
6. Noise—Any unwanted sound. Hazardous noise exists wherever an operation or process generates noise of sufficient duration and intensity to be capable of producing a permanent loss of hearing in an unprotected person. A noise hazard area is any work area with a noise level of 85 dBA or greater.
7. Sound Pressure Level—A sound measurement expressed in decibels obtained with a sound level meter (SLM) that has a flat frequency response.
8. Time-Weighted Average (TWA)—The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be exposed repeatedly, day after day, without adverse effect.

2.9.3 General

Occupational exposure to noise has been shown to be a contributing factor in the development of noise-induced hearing loss. Loss of hearing can result from exposure to impact noise and/or steady-state, continuous/intermittent noise. The hearing loss may be temporary or may become permanent through repeated exposure of unprotected personnel to hazardous noise. Initial deterioration of hearing may not be apparent to the individual until the impairment becomes substantial and irreversible.

It is NASA policy to control noise generated in their facilities and to prevent occupational noise-related hearing loss. Maximum permissible exposure limits have been established as listed in Table 2 and Table 3, below. Priority will be given to ensuring that engineering procedures are used to the greatest extent practical to eliminate, control, or isolate sources of hazardous noise.

2.9.4 Design/Operational Requirements

1. Employees routinely exposed to noise (30 or more days per year) at or above the action level shall be placed in a hearing conservation program. Employees shall never be exposed to noise above the permissible limits specified in Tables 1 and 2. The hearing program shall consist of:
   - Baseline medical monitoring and annual re-examination, and record keeping of results.
   - Annual training on types of hearing protection available, use of hearing protection (including limitations), other means of reducing noise exposure, noise monitoring, effects of noise on hearing, purpose of medical monitoring, and care of hearing protectors.
   - Use of hearing protection by employees exposed to continuous noise in excess of 85 dBA TWA.
   - Area noise surveys.
2. Noise control and reduction considerations shall be integral to the site selection and design of new or modified MSD facilities. Where feasible, newly designed or purchased equipment shall be of the type that minimizes any noise exposure hazard to personnel. Engineering controls shall be designed into new or upgraded facilities. If possible, noisy equipment shall be installed in buildings or building areas apart from personnel activities. Acoustic tile and other noise attenuating materials should be installed where practical.
3. Managers and supervisors shall conduct noise surveys of their facilities and equipment, and notify S&EB where exposure levels are expected to exceed the limits specified in Table 2 and Table 3, below. S&EB shall conduct baseline noise surveys and recommend appropriate means of controlling noise exposure.
4. Personnel who work in MSD facilities or perform operations known to have hazardous noise levels shall be placed in a hearing conservation program and undergo periodic audiograms. Examples of MSD facilities or operations with hazardous noise levels include the vibration facility, machine shops, cleanroom fan rooms, areas near the nitrogen gas vaporizers, and areas near environmental control systems aboard spacecraft transporters.
5. Personnel who work in and around noisy environments shall wear the appropriate PPE (Section 3.6). Hearing protection devices shall be made available to personnel who work in or around noise producing areas. These include earplugs, ear canal caps, ear muffs, and ear defenders. For all types of earplugs and caps, it is important to keep them clean and wash your hands before inserting them. Disposable earplugs are available. For reusable type ear defenders, keep them clean, free from cracks, and ensure that any protective cushions/pads are properly adjusted for a snug fit.

6. If there is doubt as to an individual's noise exposure, arrange to have dosimeter checks performed by S&EB. A noise dosimeter is a special sound-level meter that can be attached directly to the individual. It measures the amount of noise exposure over a given period of time, such as an average workday. Administrative controls should be considered as a way of reducing exposure time if necessary.
7. Noise hazard warning signs, which clearly indicate the hazard of high noise levels and state the requirements to wear hearing protection shall be posted at or near noise hazard areas.
8. Operating and maintenance procedures shall include appropriate measures for controlling or restricting personnel access in and around high-noise-level environments.
9. Fail-safe engineering controls shall be used to restrict personnel from entering areas where the noise level would be immediately dangerous to life or health. For example, the acoustic reverberation chamber shall be locked during all acoustic testing, and the key shall be kept in the possession of the acoustic control system operator until after the test run is completed.

Table 2 Permissible Exposure Limits for Continuous Noise

Duration (Hours)	dBA
16.0	80
8.0	85
4.0	90
2.0	95
1.0	100
0.5	105
0.25	110
0.125 or less	115

Table 3 Permissible Exposure Limits for Impact or Impulsive Noise

Sound Level (dB peak)	Permitted Number of Impacts or Impulses Per Day
140	100
130	1,000
120	10,000

2.9.5 GSFC Contacts

Environmental Test Engineering and Integration Branch, Head: (301) 286-5072
S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.9.6 Reference Documents Unique to this Section

29 CFR 1910.95, *Occupational Noise Exposure*

29 CFR 1910, *Subpart I, Personal Protective Equipment*

NPG 1821.1, *Hearing Conservation*

2.10 Unique/Experimental Systems

2.10.1 Scope

This section covers unique and/or experimental systems that do not fit into any of the categories defined up to this point in the Safety Manual.

2.10.2 Acronyms/Definitions

N/A

2.10.3 General

Unique and/or experimental payloads may contain potentially hazardous systems that have not been defined and addressed in this Manual. For example, flight spacecraft may contain exotic fuels or gases in their propulsion and attitude control systems that have never been previously experienced in the MSD complex. Listed below are the steps necessary to obtain approval for bringing these payloads into the MSD complex.

2.10.4 Design/Operational Requirements

1. The Project shall determine whether their payload has potentially hazardous systems that are not addressed earlier in this Manual. The systems should be documented in a written hazard analysis and included in the test plan.
2. The Project Manager should call one or more of the GSFC contacts listed below and inform them of their requirements.
3. A PSTL engineer will be assigned to coordinate the MSD support. The engineer will review the Project's hazards analysis and test plan, recommend what facilities and work-arounds are suitable for the job, and arrange scheduling.
4. It may be necessary to obtain approval from the S&EB before allowing a payload to enter the complex if it contains chemicals, gases, or other materials that are harmful to personnel or equipment. The PSTL engineer can assist in this determination and recommend the appropriate S&EB contact personnel.
5. Wherever possible, potential hazards shall be eliminated completely before arrival at the MSD complex. For example, pressurized vessels that normally contain hazardous fuels shall be emptied and purged. Sometimes, water or other benign materials can be substituted for the fuel in the vessels if it is necessary to simulate launch conditions.
6. If potential hazards cannot be eliminated completely, engineering controls and other steps must be taken to mitigate the hazards. In all cases, step-by-step procedures shall be prepared for MSD approval prior to conducting the activity. Some examples of work-arounds include the following:
    - Dummy parts or systems can be fabricated and substituted for their hazardous counterparts during testing.

- The job can be performed in facilities that provide isolation. In unique circumstances, facility control systems might be modified or the facility physical characteristics modified to meet an unusual job requirement.
- Extra cleanroom facilities, purging systems, and ventilating systems might be set up near the job site.
- Specialized monitoring equipment and sensors can be set up with automatic alarm and shut down systems. Limiters can be installed to prevent overtest conditions. Redundant signal conditioning, acquisition, and analysis systems can be installed to ensure fail-safe conditions.
- Specialized emergency equipment and materials may be obtained and installed at the job site. For example, this might include extra fire protection or spill recovery systems.
- Hazardous activities can be scheduled to occur after normal working shifts to reduce personnel exposure.
- Handling and operations personnel might receive specialized training necessary to perform a unique activity.
- Specialized PPE such as full dress hazard garments might be obtained and used for a unique activity. Custom-designed protective barriers could be obtained.

7. It may be necessary to preclude a payload from entering the MSD complex if the potential hazards cannot be eliminated altogether or mitigated safely through the use of engineering controls and work-arounds. The PSTL engineer will notify the Project if no practical solutions can be devised for a unique requirement.

2.10.5 GSFC Contacts

Project Support Team Lead, Head: (301) 286-5072
Environmental Test Engineering and Integration Branch, Head: (301) 286-5072
S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.10.6 Reference Documents Unique to this Section

N/A

2.11 Confined Spaces

2.11.1 Scope

This section covers the minimum requirements for constructing and working in a confined space. It will not define hazardous materials, which is covered in Section 2.5. Lockout/tagout requirements are discussed in Section 3.8.

2.11.2 Acronyms/Definitions

1. Attendant—An individual stationed outside one or more permit spaces who monitors the authorized entrants as well as activities inside and outside the space.
2. Authorized Entrant—An employee who has received the training and possesses the skills necessary to safely enter and work in a confined space and who has authorization to do so from his/her employer.
3. Confined Space—A space that:
   - Is large enough and so configured that an employee can enter bodily and perform assigned work;
   - Has limited or restricted means for entry or exit; and
   - Is not designed for continuous employee occupancy.
4. Confined Space Monitor—A person empowered by management to perform permitting duties and responsibilities for confined space operations. This person must have had additional training in confined space entry and must be approved by the S&EB.
5. Engulfment—The surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be inhaled to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.
6. Entry—The act by which a person passes through an opening into a confined space. This occurs as soon as any part of the body breaks the plane of an opening into the space.
7. Hazardous Atmosphere—An atmosphere that may expose employee to the risk of death, incapacitation, impairment of ability to self-rescue, injury, or acute illness, from one or more of the following causes:
   - Flammable gas, vapor, or mist in excess of 10% of its lower flammable limit (LFL).
   - Airborne combustible dust at a concentration that meets or exceeds its LFL.
   - Atmospheric oxygen concentrations below 19.5% or above 23.5%.
   - Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in the Occupational Safety and Health Administration (OSHA) regulations or the American Conference of Governmental Industrial Hygienists (ACGIH) and which could result in employee exposure in excess of the dose or permissible exposure limit.

- Any other atmospheric condition that is Immediately Dangerous to Life or Health (IDLH).

8. Immediately Dangerous to Life or Health (IDLH)—Any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a confined space.
9. Low-Hazard Permit Space—A permit-required confined space where there is an extremely low likelihood that an IDLH or engulfment hazard could be present, and where all other serious hazards have been controlled.
10. Oxygen Deficient Atmosphere—An atmosphere containing less than 19.5% oxygen by volume.
11. Oxygen Enriched Atmosphere—An atmosphere containing more than 23.5% oxygen by volume.
12. Permit-required Confined Space—A confined space that has one or more of the following characteristics:
    - Contains or has a potential to contain a hazardous atmosphere.
    - Contains a material that has the potential for engulfing an entrant.
    - Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
    - Contains any other recognized serious safety or health hazard (temperature extremes, radiation, biological, noise, vibration, etc.).

2.11.3 General

Confined spaces within the MSD facility include the High Capacity Centrifuge (HCC) pit, underground cable trays at the Magnetic Test Facility, the space behind the Space Environment Simulation (SES) test chamber shrouds, and the bilge under the SES. Other types of confined spaces may include transporters and vacuum chambers when the access is limited and hazards are introduced (GN_2 purging, painting, welding, etc.).
Thermal vacuum chambers are a special case of confined space. After the chamber has been run and the area verified safe, the chamber can be opened for entry by untrained personnel, as long as the test item or work being performed in the chamber does not introduce hazards that may affect the atmosphere.

2.11.4 Operational Requirements

1. In general, personnel should not be exposed to the hazards of a confined space when engineering controls can be established.
2. Personnel entering the confined space and attendants must be trained in entry procedures and hazards.

3. Training must include: duties and responsibilities of attendants and entrants, hazard recognition, communication, proper use of protective equipment, permit requirements, and non-entry rescue requirements.
4. The area must be posted with a "Danger" sign indicating the hazard.
5. GSFC Permit Form 23-52 must be completed and posted.
6. Area monitoring and/or ventilation is required if the atmosphere presents or can present a hazard.
7. Additional lighting is required if provided lighting is not adequate for the task.
8. All hazardous energy sources (power, pneumatic, etc.) must be secured by lockout/tagout procedure/permits.
9. Only explosion-proof electrical equipment meeting Article 500 of the *National Electric Code* and non-sparking tools may be used in spaces that may contain flammable atmosphere.
10. Permit-required spaces require written procedures approved by the applicable safety organization in order to perform work.
11. Hot work (welding, cutting, brazing, sparks/flames, etc.) requires additional permitting.
12. Only those personnel specifically trained in rescue operations and properly equipped shall enter a confined space to rescue personnel.

2.11.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

2.11.6 Reference Documents Unique to this Section

ANSI Z117.1-1989, *Safety Requirements for Confined Spaces*

Code of Maryland Regulations for Confined Spaces

GMI 1780.1, *GSFC Confined Space Policy*

NHS/IH-1845.2, *Entry into and Work in Confined Spaces*

OSHA 29 CFR 1910.146, *Permit-Required Confined Spaces*

3.0 Additional Operations Requirements

3.1 Working at Heights

3.1.1 Unprotected Heights/Fall Protection

3.1.1.1 Scope

This section describes the requirements for working at unprotected heights with fall protection.

3.1.1.2 Acronyms/Definitions

1. Fall arresters, shock absorbers, or deceleration device—A device that slows a worker's fall or breaks the fall to prevent injury, usually by rip stitches, specially woven lanyard, tearing or deforming lanyard, rope grab, or automatic self-retracting lifeline. Such a device dissipates a substantial amount of energy during a fall.
2. Free fall—The act of falling before the personal fall arrest system begins to apply force to arrest the fall.
3. Lifeline—A component consisting of a flexible line for connection to an anchorage at one end to hang vertically (vertical lifeline), or for connection to anchor at both ends to stretch horizontally (horizontal lifeline), and which serves as a means for connecting other components of a personal fall arrest system to the anchorage.
4. Restraint device—A device where the lanyard is sized such that the worker can just reach the farthest point on a platform without actually reaching the edge.
5. Safety belt or body belt—A strap worn snugly around the waist.
6. Safety harness—Straps worn around parts other than the soft tissue areas of the body.
7. Standard handrails—A rail system constructed such that the smooth top rail is 42 inches (107 cm) high nominal, the intermediate rail is halfway between the top rail and the platform, and the system has a nominal four-inch (10 cm) toeboard. The top rail must withstand a minimum of 200 pounds (91 kg) load applied in any direction.
8. Unprotected heights—Any work platform over four feet above the floor or adjacent work platform or ground which does not have standard handrails, except where there are stairs or a fixed ladder.

3.1.1.3 General

Working at unprotected heights is prohibited. Whenever platforms do not have standard handrails installed, fall protection shall be provided. Areas below personnel working at heights shall be roped off and signs posted to keep personnel out of the hazard area. Tools and all loose items shall be tethered to prevent them from falling on personnel and equipment below.

3.1.1.4 Design/Operational Requirements

1. Floor openings and hatchways must be guarded by a standard handrail on all exposed sides or be protected by a suitable cover.
2. Personnel who are uncomfortable working at heights shall not be assigned to perform such work.
3. Anchorage points for lanyards must be able to withstand a 5,000-lb (2,268 kg) static load per person.
4. Lanyards shall have a minimum breaking strength of 5,000 lb (2,268 kg).
5. Retracting lifelines that limit free fall to two feet (0.061m) or less must be able to sustain a minimum static tensile load of 3,000 lb (1,361 kg). If the free fall is greater than two feet (0.061m), the lifeline must sustain a minimum static tensile load of 5,000 lb (2,268 kg).
6. Horizontal lifelines shall be designed and installed as part of a complete personal fall arrest system, which maintains a safety factor of at least two, under the supervision of a qualified person.
7. Employees using fall protection shall be trained annually in the proper care and use of the specific equipment.
8. Safety belts shall not be used for fall protection; harnesses must be used. Belts may be used for fall restraint only. Fall restraint allows the individual to approach a precipice or hazard area, but is short enough to prevent the possibility of an actual fall.
9. Each time fall protection is used, it shall be inspected by the user for wear, mildew, damage or other deterioration, and defective components. Fall protection devices shall be inspected annually by a competent person to verify that they are not damaged.
10. Fall protection devices should be stored in dry locations, free from dirt, chemical exposure, or exposure to sunlight.
11. Lanyards must be attached above head height and at the center D-ring of the back of the harness. Free falls should be kept to the shortest distance possible, no greater than six feet (1.83 m), nor should they contact any lower level.
12. Retracting lifeline devices shall be inspected prior to use by the employee using the device and annually by a competent person.
13. Fall arresters and shock absorbers are preferred over lanyards without the devices.
14. If any part of a fall arrest system is involved in a fall, it shall immediately be removed from service and replaced.
15. Lanyard and lifelines shall never be knotted, tied around sharp edges, or attached back on themselves, or over or around rough surfaces. Tie-off using a knot in a rope lanyard or lifeline can reduce the strength by 50% or more. Tie-off around an H-beam or I-beam or similar support can reduce the device's strength as much as 70% due to the cutting action of the beam edges.

16. The following conditions require locking snap-hooks on lanyards due to possible roll-out from non-locking hooks:
    - Direct connection to a horizontal lifeline;
    - Two snap-hooks connected to one D-ring;
    - Two snap-hooks connected to each other;
    - A snap-hook connected back on its integral lanyard;
    - A snap-hook connected to a webbing loop or webbing lanyard; or
    - The dimensions of the D-ring, rebar, or other connection point would allow the keeper to be depressed (i.e., opened) by a turning motion of the snap-hook.
17. Side, front, and chest D-rings should be used for positioning only. Shoulder D-rings should be used for retrieval only.
18. Safety nets may be used when work places are more than 25 feet (7.6 m) above the ground or other surface and other means of fall protection are impractical. If used, nets must be installed as close to the work level as possible and tested before beginning operations, in accordance with ANSI A10.11 and OSHA.
19. Fall protection must be used on crane platforms when handrails are not present or the bridge cannot be located close to (within 12 inches [30.5 cm] of) the access platform.
20. If someone falls and is suspended by their fall protection, immediately summon trained rescue personnel by calling the Emergency Console (112).

3.1.1.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.1.1.6 Reference Documents Unique to this Section

29 CFR 1910, *Subpart D—Walking-Working Surfaces*

29 CFR 1910, *Subpart F—Powered Platform, Manlifts, and Vehicle-Mounted Work Platforms*

19 CFR 1926.105, *Safety Nets*

ANSI A10.8, *Safety Requirements for Scaffolding*

ANSI A10.11-1989, *Safety Nets Used During Construction, Repair, and Demolition Operations*

ANSI A14.1, *Safety Requirements for Portable Wood Ladders*

ANSI A14.2, *Safety Requirements for Portable Metal Ladders*

ANSI A14.3, *Safety Requirements for Fixed Ladders*

ANSI A14.4, *Safety Requirements for Job-Made Ladders*

ANSI A14.5, *Safety Requirements for Portable Reinforced Plastic Ladders*

ANSI A92.3, *Manually Propelled Elevating Aerial Platforms*

ANSI A92.5, *Boom-Supported Elevating Work Platforms*

ANSI A92.6, *Self-Propelled Elevating Work Platforms*

3.1.2 Ladders

3.1.2.1 Scope

This section describes the requirements for working with ladders.

3.1.2.2 Acronyms/Definitions

See Section 3.1.1.2.

3.1.2.3 General

No matter how familiar personnel are with ladders and how harmless they seem, ladders account for a considerable percentage of accidents. Working from ladders can be extremely hazardous if the ladders are not in good condition or if they are not used properly.

3.1.2.4 Design/Operational Requirements

1. Ladders shall be manufactured per the requirements of OSHA and ANSI. Manufacturer's labels usually state the standards they meet.
2. A competent person shall inspect all ladders for damage annually, and shall tag each ladder with the inspection date, inspector's initials, and due date. A record of the inspection shall be kept on file.
3. Each time a ladder is used, the person using it shall inspect it.
4. Defective ladders shall be taken out of service immediately, and tagged or marked as "Dangerous, Do Not Use" until repaired or discarded.
5. Never paint a ladder.
6. Never stand on the top two rungs of portable ladders.
7. Never use conductive or metal ladders for electrical work.
8. When using a ladder to access a high place (traversing to a platform or leaning over to the point that the center of gravity is not centered with the ladder), lash it or have another person keep it from slipping or moving.
9. Never stand or work with one foot on the ladder and one foot on a raised platform.
10. Ladders must extend at least three feet (0.91 m) above upper surfaces being accessed.
11. Do not overload ladders. Manufacturer's labels state the maximum weight allowed.
12. Store ladders where they will not be exposed to the weather and where there is good ventilation. Do not store ladders where they would present a tripping hazard.
13. Place extension and straight ladders so the horizontal distance from the base to the vertical plane of the support is approximately one-fourth the ladder's height between supports.
14. Secure both the bottom and top of a ladder to prevent displacement when using the ladder to access a scaffold.
15. Always hold on with both hands and face the ladder when ascending or descending. If you need to use both hands to work while on a stepladder, use a safety belt or hook one leg around a rung.

16. Stepladders must be fully open and the spreader locked before using.
17. Stepladders shall not be longer than 20 feet (6.1 m).
18. Do not use ladders in front of doors unless the door is blocked, locked, or guarded.
19. Type III light duty ladders shall not be used. Type I industrial ladders are preferred for all applications. However, Type II commercial ladders for medium duty may be used in offices.

3.1.2.5 GSFC Contacts

See Section 3.1.1.5.

3.1.2.6 Reference Documents Unique to this Section

See Section 3.1.1.6.

3.1.3 Scaffolds

3.1.3.1 Scope

This section describes the requirements for working with scaffolds.

3.1.3.2 Acronyms/Definitions

See Section 3.1.1.2.

3.1.3.3 General

Scaffolds have many applications within the MSD. Typically, tube and coupling and tubular welded frame scaffolds are used. Personnel must be able to distinguish scaffolding types and ensure compatibility of parts when erecting scaffolds. For example, scaffolding tubing might be either steel or aluminum, and may have different diameters and wall thicknesses, which must be mated to appropriately-sized couplers. When scaffolding is leased or purchased, safety instructions for erection and use should accompany the equipment.

3.1.3.4 Design/Operational Requirements

1. Scaffolds and their components shall be capable of supporting without failure at least four times the maximum intended load. Load rating shall be marked on scaffolds.
2. Only heavy-duty (designed to hold a load of 75 lb/ft^2 [366 kg/m^2]) or medium duty (designed to hold a load of 50 lb/ft^2 [244 kg/m^2]) scaffolding shall be used in the MSD facilities.
3. Scaffolds shall be erected and used only by trained, certified personnel per OSHA 1926.454.
4. Damaged or weakened scaffolds or components shall be removed from service immediately.
5. Never interchange scaffold components of different manufacturers.
6. Scaffolds shall not be altered or moved horizontally while they are in use or occupied.
7. An access ladder or equivalent safe access shall be provided. Scaffolding manufactured by "UpRight" is designed to be climbed on the horizontal side rungs. Do not climb or stand on the diagonal braces.
8. Outriggers shall be used or the scaffold shall be tied-in to the building if the scaffold height exceeds four times the minimum base dimension.
9. Tools, materials, and debris shall not be allowed to accumulate on scaffolds.
10. Scaffolds shall be supplied with standard handrails on all open sides. Cross-bracing is acceptable in place of a midrail when the crossing point of two braces is between 20 inches (0.5 m) and 30 inches (0.8 m) above the work platform, or as a toprail when the crossing point of two braces is between 38 inches (0.97 m) and 48 inches (1.3 m) above the work platform.
11. Scaffold casters shall be locked when personnel are on the unit.
12. Suspended scaffolds shall be erected and used per OSHA and ANSI requirements.
13. Scaffolding shall be inspected by a qualified person before each work shift and after any change in its configuration.

3.1.3.5 GSFC Contacts

See Section 3.1.1.5.

3.1.3.6 Reference Documents Unique to this Section

OSHA 29 CFR, 1926, *Subpart L—Scaffolds*
See also Section 3.1.1.6.

3.1.4 Personnel Lifts

3.1.4.1 Scope

This section covers personnel lifts used to position personnel and necessary tools/materials at elevated work locations.

3.1.4.2 Acronyms/Definitions

1. Personnel lift—Any device that is primarily designed and used to position personnel.

See also Section 3.1.1.2.

3.1.4.3 General

Various types of personnel lifts are used within the MSD for working at heights up to 49 ft (14.8 m). These include motorized, flying-carpet-type, and cherry-picker-type lifts that have hydraulic and/or pneumatic elevating mechanisms. Typically, the electrical batteries that power these lifts must be recharged overnight, or after heavy duty cycles.

3.1.4.4 Design/Operational Requirements

1. Equipment Certification:
   - Aerial lifts used on MSD properties shall be designed and constructed in conformance with the applicable requirements of the American National Standard for *Self-Propelled Elevating Work Platforms*, ANSI/SIA-92.6.
   - All MSD elevated work platforms are formally certified/recertified by the RECERT Manager.
2. Operator Training and Medicals:
   - Only trained and qualified operators shall be authorized to operate GSFC self-propelled elevating work platforms. Training/requalification shall be performed every year. Medicals are required every three years.
3. General Requirements:
   - The operator shall ensure that the aerial device is used only for applications as defined in the operating manual and that recognized safety practices are observed.
   - Altering or disabling safety devices, guards, or interlocks is prohibited.
4. A copy of the manufacturer's manual shall be maintained with each lift.
5. Personnel lifts shall be inspected by a qualified mechanic on an annual basis.
6. Prior to each day's use the operator shall inspect the lift. Initial the Logbook upon completion of inspection, noting any discrepancies.
7. Any time a discrepancy is noted during an inspection or use, the equipment shall be taken from service immediately and tagged.
8. Never overload a personnel lift. Weight limitations are marked on the equipment.
9. Personnel lifts shall not be used as a materials handling device unless designed and equipped by the OEM for such purpose.

10. Battery charging shall be performed only in designated locations (see Section 2.4.1 for information on battery charging).
11. Safety belts or harnesses with a lanyard attached to the device shall be worn by personnel using a personnel lift that is equipped with attach points, such as a bucket type lift.
12. Personnel must adhere to the following: never sit or climb on the edge of the platform/bucket; always stand firmly on the platform/bucket floor; never stand on boxes, planks, railing or other devices in the platform/bucket.
13. When used around critical or flight hardware, personnel lifts should be kept parallel to the hardware whenever possible. Do not approach hardware head-on.
14. Do not use personnel lifts around electric power lines unless the lines are de-energized or adequate clearance is maintained.
15. Outriggers shall always be used when the personnel lift is so equipped.

3.1.4.5 GSFC Contacts

See Sections 2.1.1.5 and 3.1.1.5.

3.1.4.6 Reference Documents Unique to this Section

ANSI A92.3, *Manually Propelled Elevating Aerial Platforms*

ANSI A92.5, *Boom-Supported Elevating Work Platforms*

ANSI A92.6, *Self-Propelled Elevating Work Platforms*

ANSI/SIA A92.2 and OSHA CFR 1910.67, *Vehicle-Mounted Elevating and Rotating Aerial Devices*

3.2 Hand Tools and Miscellaneous Powered Equipment

3.2.1 Scope

This section covers hand tools and other miscellaneous powered equipment such as portable drills, circular saws, grinders, impact wrenches/hammers, vacuum cleaners, buffers/polishers, heat guns, jacks, pressurized cleaners, etc.

3.2.2 Acronyms/Definitions

N/A

3.2.3 General

Hand tools and miscellaneous powered equipment are commonplace in the MSD complex. Employees must understand the most common hazards of their operation, which are:

- Injuries from contact with unguarded points of operation, such as saw blades or drill bits.
- Shock, fire, and electrocution from electrical problems.
- Injury from flying pieces, dust, shavings, etc.
- Injury from heat, pressure, hydraulic fluids, cooling oils, etc.
- Injury caused by defective equipment or improper use of the equipment.

3.2.4 Design/Operational Requirements

Employees who work with hand tools and powered equipment shall be responsible for inspecting them before each use to verify that they are in proper working condition, with all safety guards in place and effective. Guidelines for this equipment are as follows:

1. Always wear PPE appropriate for the job at hand (see Section 3.6). Safety goggles are a must to protect the eyes from flying debris, dust, and chips. Other PPE includes hard hats, safety shoes, dust filter or respirators with the appropriate filter cartridges, gloves, hearing protection, and garments which protect the body but are not prone to snagging in moving mechanisms.
2. Avoid the following unsafe acts:
    - Unauthorized operation or use of equipment.
    - Using defective tools or equipment, or using them improperly.
    - Operating equipment at an unsafe speed.
    - Poor housekeeping (failure to put things away when not in use or to dispose of trash properly).
    - Removing or bypassing safety devices.
    - Riding moving equipment not designed for that purpose.
    - Failure to warn or signal as required.
    - Standing in an unsafe place or taking an unsafe posture.

- Indulging in horseplay, or distracting or startling other employees.
- Failure to wear the appropriate PPE.

3. Unsafe conditions might exist which require the help of other people or organizations to correct them. For the unsafe conditions listed below, the employee can take corrective actions such as returning unsafe tools or rendering them unusable, then tagging them, and alerting maintenance sections; reporting unsafe conditions to their supervisor or safety contacts; and suggesting methods to correct unsafe conditions. The following are specific unsafe conditions:
   - Lack of adequate guards or safety devices.
   - Lack of adequate warning systems.
   - Fire and explosion hazards.
   - Improper or inadequate PPE available.
   - Poor ventilation.
   - Protruding object hazards.
   - Close clearance and congestion hazards.
   - Hazardous arrangement of workstations.
   - Inadequate illumination or hazardous noise.
   - Defective tools and equipment, or lack of the proper tools for the job.
4. OSHA requires machine guards and constant pressure switches and controls on many types of equipment. For example, grinders have face shields and grinding wheel containment housings; saws have blade shields and adjustable anti-kickback mechanisms; and many tools have safety guards at the point of operation that exposes the operator to injury. Some guards are fixed in place, while others must be adjusted by the operator for the job at hand. Employees must never remove or bypass these devices when using the equipment. Always replace the guards after machine maintenance or repair. Never tape down or circumvent pressure switches that automatically turn off machinery when the operator releases hand or foot pressure on the controls. (See Section 4.7.4 Item 8 for further safety guard information.)
5. Follow these safety rules when working with powered equipment:
   - Check that connectors and insulation on the electrical cords are in good condition.
   - Verify that tools are properly grounded (three wire cords/plugs or double insulated). Tools that are double insulated in their design to prevent electrical shock hazard may be plugged into ordinary outlets. All tools that are not double insulated shall be plugged into power outlets, which are protected by ground fault interrupter (GFI) devices. Correctly match plugs to outlets, and never modify a plug to adapt to an inappropriate outlet. Plugs and outlets are designed with different physical geometry according to voltage, current, and power needs (i.e., three pronged, four pronged, small or large sized prongs, right-angled prongs, etc.).

- Where possible, avoid using electrical extension cords; however, if they are necessary, ensure that they are rated high enough for the job, and route them where they don't cause tripping or snagging problems.
- Be sure hands are dry before handling electrical tools.
- Immediately turn off and tag out of service any tool that smokes, smells, sparks, or shocks.

6. Specialized equipment may be powered by compressed air (e.g., pneumatic drills and wrenches) or hydraulic systems (e.g., hydraulic jacks). Observe these guidelines when maintaining or operating such equipment:
   - Before using the equipment, inspect air hoses, hydraulic lines, connections, and fittings; keep them clean and free of kinking, cracking, tangling, etc.
   - Air hoses and hydraulic lines shall be designed for the maximum pressure and service to which they are subjected, and shall have adequate restraining mechanisms in case of failure.
   - For pneumatic tools, a tool retainer shall be installed on each piece of equipment, which keeps the tool from being ejected under pressure.
   - Be sure the service pressure and capacity are appropriately sized for the manufacturer's operating specifications.
   - Air hoses and hydraulic lines shall be certified prior to use and periodically recertified (see Section 2.3.1.4).
7. Workers can prevent injuries involving power tools by treating them with respect and following these basic safety procedures:
   - Choose the right tool for the job.
   - Inspect each tool before use to be sure it has all its parts and they are in good working order.
   - Air hoses and hydraulic lines shall be certified prior to initial use and periodically recertified (see Section 2.3.1.4).
   - Keep tools properly lubricated and free of dust, dirt, and grime.
   - Compressed air shall not be used for cleaning purposes, except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE.
   - Follow manufacturer's instructions for using the tool, including changing blades, bits, heads, etc.
   - Don't load a tool with fasteners until you are ready to use it, and don't leave a tool loaded with fasteners unattended.
   - Don't wear loose garments, jewelry, loose long hair, or other items that can catch in machinery.
   - Keep the work area free of anything flammable that could catch fire from a tool spark.

- Alert personnel in the area of your actions. Cordon off the work zone or erect barriers to keep unauthorized personnel away from the work site.
- Keep tools not in use in a safe place where they cannot get turned on accidentally or fall on someone.
- When working at heights or above other workers or equipment, remove loose items from pockets and tether the tools to keep them from falling and causing injury or damage. The area beneath personnel working at heights must be roped off and signs posted to keep personnel out.
- Clamp work securely to prevent its movement while drilling, sanding, etc.
- Attach chuck key to the power cord so it must be unplugged before inserting the key in the chuck.
- Check the operation for possible pinch points. Allow adequate clearance for any potential movements of the work piece or shifting of the body.
- Always cut or move the tool away from, not toward, any parts of the body.
- Direct spray cleaning fluids away from the body and wear the appropriate PPE to prevent exposure to steam, cold water, etc.

3.2.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.2.6 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.242 *Hand and Portable Powered Tools and Equipment, General*

OSHA 29 CFR Part 1910.243 *Guarding of Portable Powered Tools*

OSHA 3067 *Concepts and Techniques of Machine Safeguarding*

3.3 Storm Codes

3.3.1 Scope

This section covers the storm code warning system.

3.3.2 Acronyms/Definitions

Code 1 (Alert):	Thunderstorms approaching within a few hours. Winds may be in excess of 50 MPH. Freezing or frozen precipitation that could accumulate on wires or trees
Code 2 (Warning):	Thunderstorms confirmed within one hour of reaching GSFC. Winds confirmed within one hour of GSFC. Freezing precipitation—a confirmed buildup on trees, wires, etc.—has l in progress for three hours and the forecast is for buildup to continue.
Code 3 (Action):	Storm within 30 minutes of GSFC. Lightning and rain. Winds. Freezing precipitation—trees and wires loaded to possible breaking poi impact to electrical systems could result.
Code 4 (All clear):	Resume normal operations.
Code 5 (High winds):	Winds over 35 MPH in the area.

3.3.3 General

Certain critical MSD facilities and computer areas could be affected by weather conditions, which might interrupt electrical service. Many facilities have operating procedures that mandate approved waivers before operations are allowed under Code 3 condition. The MSD has arranged with the GSFC Emergency Console (x6-8080) to contact specific areas within MSD, on a 24-hour-per-day basis, whenever there is a weather alert.

3.3.4 Design/Operational Requirements

1. The GSFC Emergency Console (x6-8080) obtains weather alerts from the National Weather Service. When the alert is received, the Emergency Console transmits the weather code status to critical areas via the phone mail message system. Designated personnel in each area (e.g., shift leader in thermal vacuum facility) notify the appropriate personnel of the weather code status.
2. Color-coded, illuminated, weather condition displays have been installed in some facilities so that all personnel in the area can obtain the current weather conditions at a glance. The MSD

is in the process of upgrading all of these displays so they can be activated automatically from a central computer source. For example, the displays in the Building 29 high bay and clean room are activated automatically whenever a new alert signal is received from the National Weather Service. For displays that have not been connected to automatic systems, the designated personnel who receive the alerts on the phone mail system must activate the displays.

3. MSD managers and supervisors shall conduct surveys of their areas of responsibility to determine which facilities and equipment would be affected by adverse weather conditions. They shall arrange to have the appropriate personnel notified of any changes in status of the weather codes. Examples of areas that could be affected by Codes 3 condition are: vibration lab, thermal vacuum facilities, high capacity centrifuge, clean rooms, computer operations, magnetic test site, crane handling operations, ordnance operations, etc.
4. Maintenance and operating procedures for critical facilities and equipment shall include a section that specifies the appropriate action to be taken for the different weather codes. In some cases, testing would be precluded unless an approved waiver is in place, as described below. Procedures shall describe emergency actions necessary to secure equipment when the weather code status changes while a test is in progress, such as during a long-term thermal vacuum test.
5. Procedures shall specify the weather code circumstances under which a waiver is required to conduct operations or perform testing (normally Codes 3). The waivers shall be signed by the applicable section head (or designee) and project representative.
6. Building FOMs shall be responsible for surveying equipment and materials on the grounds outside the buildings. They shall take steps necessary to ensure that equipment and materials are protected from rain, sleet, hail, snow, lightning, etc. These items may have to be shielded from the elements with protective coverings or secured from the dangers of high winds by restraining mechanisms.
7. Mobile crane operations must not be conducted during Codes 3 conditions. Ordnance operations must be suspended during Code 3 conditions. The following operations require a waiver to continue operations during Code 3 conditions: vibration, EMC/EMI, acoustics, HCC, and critical lifting operations within the buildings. Thermal vacuum operations continue during Code 3, but MSD recommends that Projects place their spacecraft in a secure mode.

3.3.5 GSFC Contacts

Emergency Console: (301) 286-8080
S&EB: (301) 286-2281
AETD Safety Manager: (301)286-3816
MSD Safety Lead: (310)286-1034
Support Contractor Safety: (301) 286-1035

3.3.6 Reference Documents Unique to this Section

NPD 8710.1, *Emergency Preparedness Program*

NPG 8715.2, Emergency Preparedness Plan Procedure & Guidelines

3.4 Welding, Brazing, and Cutting

3.4.1 Scope

This section covers welding, brazing, and cutting operations.

3.4.2 Acronyms/Definitions

1. Brazing—Metal joining process using high heat and a filler metal.
2. Performance Qualification—The documented demonstration of a welding or brazing operator's ability to produce welds or brazes meeting prescribed standards.
3. Thermal Cutting—Cutting process, which melts the metal (material) to be cut.
4. Weld—A localized coalescence of metals produced either by heating the materials to suitable temperatures—with or without the application of pressure—or by the application of pressure alone, and with or without the use of filler material.
5. Welding Operator—One who operates welding equipment.

3.4.3 General

Welders shall be trained and certified, and their work product shall undergo quality assurance inspections. Personnel who operate welding machines shall also be responsible for posting warning signs and protecting bystanders and equipment/facilities.
The hazards generally associated with welding are hot sparks, radiant energies, air contamination, electrical shock, chipping slag, flammable liquids and gases, and handling of compressed gases. There is always the potential for fire or explosion in the welding area. Laser welding requires special operating and personnel access control procedures, which must be approved by S&EB.

3.4.4 Design/Operational Requirements

1. In general, welders shall be properly instructed and qualified to maintain and operate the equipment per ANSI Z49.1 and OSHA 1910.252.
2. Welders required to work on flight hardware or other high-dollar-value hardware shall be trained and certified to the qualification requirements of MIL Std 1595 (or equivalent certification standard). Their work product shall pass an independent quality assurance inspection to MIL Std 1595 specifications on a yearly basis. Laser welding operators need training and eye examinations that comply with GMI 1860.3 and ANSI Z136.1 requirements.
3. Personnel performing welding or brazing on ground-based pressure vessels/systems shall be certified per GMI 1710.4. For welding on lifting devices personnel must be certified per NASA-STD-8719.9.
4. All persons exposed to welding/cutting/brazing hazards (workers, observers, and their immediate supervisors) shall be trained in the use of, and understand the reasons for, protective clothing and equipment. Section 3.6 details PPE training and use requirements.

- Respiratory protection—If gases, dusts, fumes, and particulate matter cannot be kept below threshold limits, welders shall wear respiratory protection. Inert gas shielded arc welding requires additional precautions, such as positive ventilation or local exhaust removal.
- Eye protection – Welders and their helpers shall wear goggles, helmets, and shields that give maximum protection for each welding and cutting process. These items shall conform to ANSI Z87.1. Consult the ANSI/AWS F2.2-89 Lens Shade Selector Chart for the minimum protective shade needed for a particular job. Welders in the welding shop usually wear shields with a protective shade #10.
- Gloves—Wear flame resistant gauntlet gloves of leather or other suitable material. They may be insulated for heat.
- Aprons—Wear flame resistant aprons of leather to withstand radiated heat and sparks.
- Boots/leggings—For heavy work, wear fire resistant leggings, high boots, or similar protection.
- Safety shoes—Wear safety shoes for heavy work protection. Never wear low-cut shoes with unprotected tops, because of the spark hazard.
- Safety hats—Wear safety helmets for protection against sharp or falling objects.
- Overhead work gear—For overhead work, wear capes or shoulder covers of leather. Skull caps of leather may be worn under helmets to prevent head burns. Protect the ears from sparks with wire screen protectors or equivalent means.
- General garment rules—Wear dark, wool clothing instead of light, cotton clothing. Dark clothing offers more protection against ultraviolet and infrared radiation skin burns, and wool is more resistant to deterioration and is not readily ignited. Clothing should be reasonably free from oil and grease. Keep sleeves and collars buttoned. Aprons should not have pockets to catch sparks; trousers should not have turned up cuffs. Thermal insulated underwear is designed to be worn only under outer clothing, and should not be exposed to open flames or sparks.

5. If the nature of the work permits, the welding should be accomplished near a fume hood to remove hazardous materials. (See Section 2.5.4 for fume hood inspection requirements.)
6. If welding or cutting involves asbestos, special procedures shall be approved by the S&EB. It may be necessary to contract with a company that is certified for handling and removing asbestos.
7. Electric arcs and gas flames produce ultraviolet and infrared rays. Use welding blankets or shields to protect personnel not involved in the welding operation.
8. In welding and associated work, noise levels may exceed the permissible limits (Section 2.9). Appropriate hearing protection shall be worn in such cases.
9. Regulators can be a potential hazard if they are maintained or used improperly. Regulator burnout (RBO) is an oxygen regulator fire or explosion. The following guidelines can help you prevent RBO:

- Verify that all connecting hoses are clean, unobstructed, and free of cracks, kinks and defects.
- Always close valves and bleed down hoses when finished work for the day.

10. Hazards in the operation of resistance welding equipment include the following: lack of point-of-operation guards, flying hot metallic particles, improper handling of materials, and unauthorized adjustments and repairs. These may cause eye injuries, burns, and electrical shock.
11. Arc welding uses two electrical leads: the electrode lead and the work lead. Guidelines for arc welding are:
    - The welder shall be insulated from the work and from the metal electrode and holder. The bare metal part of the electrode shall never be permitted to touch the welder's bare skin or wet clothing. Use well insulated electrodes, holders, and cables; and keep clothing, hands, and body dry. Never change electrodes with bare hands or wet gloves, or when standing on wet floors or grounded surfaces.
    - Ground the frame of portable or stationary welding units in accordance with the NEC, NFPA 70.
12. Welders must be specially trained to operate tungsten inert gas (TIG) arc welding equipment.
13. Only trained and certified personnel shall operate laser welding equipment such as the LASAG. The area must be properly posted for this type of equipment. (See Section 2.6.4 Item 8 for further laser information.)
14. Permanent welding areas shall have fire protection according to ANSI Z49.1 and NFPA 51B.
15. For welding jobs outside the shop areas, the following guidelines apply: a hot work permit is mandatory; the welder must ensure that welding activities (i.e., light and fumes) do not inadvertently activate fire alarm systems; hot work permits must be obtained from the S&EB (or other authority as designated by the MSD) at least 48 hours before beginning any hot work; and the Facilities Management Division (FMD) shall approve, in advance, any work that affects GSFC building operations. The following forms are necessary to request a hot work permit:
    - Form GSFC 23-4 Hot Work Approval - Approved by an authorized person/S&EB. If the work will impact building utility systems, then a Utility Outage Request Form is needed also (see below).
    - Form GSFC 23-4A Hot Work Supplement Log Sheet – Form completed each day by the employee performing the work to verify the area was properly inspected.
    - Utility Outage Request Form—Obtain this form and approvals from the FMD. The form addresses the areas and systems, which may be impacted by the work being done on the hot work permit.
16. The following welding requirements ensure protection of personnel and facilities:

- It is mandatory to provide a fire extinguisher—either multipurpose chemical or carbon dioxide—at the welding site. If welding near wood construction or combustible materials that cannot be moved, provide a fire hose, water pump tank extinguisher, or fire pails convenient to the welder.
- Prevent sparks or hot slag from reaching combustible materials. If the work cannot be moved away from such materials, then protect the materials with sheet metal covers, welding blankets, or equivalent means. Spray booths and ducts should be cleaned to remove combustible materials. Floors shall be swept clean and covered with metal or equivalent protective means.
- Hot metal or slag shall not be permitted to fall through cracks in the floors, walls, into machine tool pits, etc. Remember that hot slag can roll along the surface to out-of-the-way places.

3.4.5 GSFC Contacts

Welding Facility, Precision Assembly Group, Leader: (301) 286-3956
S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 287-1035

3.4.6 Reference Documents Unique to this Section

OSHA 29 CFR 1910 *Subpart Q, Welding, Cutting and Brazing*

ANSI/ASC Z49.1, *Safety in Welding, Cutting and Allied Processes*

ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*

ANSI/AWS F3.1-89 *Guide for Welding Fume Control*

GMI 1700.4, *GSFC Hot Work Permits*

NFPA 51B *Cutting and Welding Processes* and NFPA 70 *National Electrical Code*

MIL Standard 1595 *Qualification of Aircraft, Missiles, and Aerospace Fusion Welders*

GPG 1700.2, *Chemical Hygiene Program*

3.5 Smoking

3.5.1 Scope

This section describes the GSFC smoking policy.

3.5.2 Acronyms/Definitions

Smoking—A lighted cigar, cigarette, pipe, or any lit tobacco or plant material.

3.5.3 General

This policy is to promote good health and provide an environment reasonably free from pollutants, including tobacco smoke.

3.5.4 Design/Operational Requirements

1. Smoking is prohibited in all GSFC buildings and facilities.
2. Smoking outside of buildings is prohibited in areas posted as such.
3. Smoking at building entrances is limited to those supplied with ashtrays.

3.5.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.5.6 Reference Documents Unique to this Section

GMI 1772.1, *Center Smoking Policy*

3.6 Personal Protective Equipment

3.6.1 Scope

This section describes the requirements for using personal protective equipment (PPE). Additional information on hazardous materials, hearing protection, and working at heights may be found in Sections 2.5, 2.9, and 3.1, respectively.

3.6.2 Acronyms/Definitions

1. Immediately Dangerous to Life or Health (IDLH)—any condition that poses an immediate or delayed threat to life, or that would cause irreversible adverse health effects, or that would interfere with an individual's ability to escape unaided from a confined space.
2. NIOSH—National Institute for Occupational Safety and Health.
3. MSA—Mine Safety and Health Act.
4. PPE—Personal Protective Equipment.
5. Time-Weighted Average (TWA)—The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be exposed repeatedly, day after day, without adverse effect.

3.6.3 General

Engineering controls shall always be used in lieu of PPE. PPE shall be provided, used, and maintained in a sanitary and reliable condition whenever there are hazards that may cause injury or impairment and engineering controls have not been established. Appropriate PPE shall be provided by the employee's section or company. The employee's supervisor is responsible for ensuring that the proper PPE is used. The employee is responsible for using the equipment as required.

3.6.4 Design/Operational Requirements

1. Prior to employees being issued PPE, a hazard assessment shall be conducted to verify that the appropriate PPE is used, and the individual shall be trained in its use. Training shall include all of the following:
   - When PPE is necessary.
   - What PPE is necessary.
   - How to properly don, doff, adjust, and wear PPE.
   - Limitations of the PPE.
   - Proper care, maintenance, useful life, and disposal.
   - How to obtain PPE.

   Retraining shall be required when: new equipment is introduced, there are changes in the work site, or an employee is found not using/maintaining PPE properly. A written

certification that the employee has successfully completed training shall be maintained by each section or company.

2. Eye and face protection (prescription and non-prescription) shall meet ANSI Z87.1 and be selected for the specific job. The following lists some requirements for common hazards:
   - Safety glasses used for impact hazards shall have side shields when there is a chance of particles entering from the side.
   - Face shields must be combined with basic eye protection (safety glasses or goggles) when protecting against impact hazards.
   - The only type of goggle that may be used when working with hazardous liquids is one with indirect vents.
   - OSHA 1910.133 contains guidelines for protection against radiant energy (welding/cutting).
   - ANSI Z87.1 contains guidelines for all types of eye and face protection.
3. Prior to the use of respiratory protection, an assessment shall be made as to the type of protection needed. The assessment shall take into account type of material, quantity of material, and other methods of reducing exposure or removing the materials.
   - Only those personnel who have been medically certified to wear respiratory protection and have completed specific training, including qualitative or quantitative tests, may do so. Training and medical examinations are required annually.
   - Respiratory protection must be approved by the National Institute for Occupational Safety and Health (NIOSH) or Mine Safety and Health Act (MSA).
   - Air-purifying respirators shall never be used in oxygen-deficient atmospheres, when levels are above the protection factor, or when levels are at or near IDLH.
   - When performing maintenance on the respirator, only parts specified by the manufacturer may be used.
   - Respirators must be maintained in a clean, sanitary condition and inspected prior to each use.
4. Where there is a possibility of injury to the head from falling objects, hard hats shall be worn. Hard hats must be worn when personnel are working above one another with tools. These helmets shall meet ANSI standard Z89.1. No decals shall be affixed to hard harts, nor shall they be painted.

   Hard hats shall not be worn within six feet of flight hardware, unless protection is required from an identified head hazard, and the hazards cannot be eliminated or mitigated. Procedures allowing the removal of helmets shall contain a statement verifying no head hazards are present, signed by quality assurance, safety or project management. If it is determined that helmets are required, the appropriate project representative shall be notified prior to the start of operations. Chin straps shall be used if the possibility exists that the helmet could fall and impact another individual or hardware.

5. Where a possibility exists of injury to feet, foot protection that meets ANSI standard Z41 shall be worn. When working with heavy materials, steel-toed shoes are required. If there is a chance of puncture, puncture-resistant soles are required.
6. Gloves shall be worn to protect the hands when a hazard exists from exposure to chemicals or abrasions. For chemical exposures, gloves shall be selected based upon manufacturers' permeation tests. Leather or cotton gloves shall be used when the possibility of abrasion or splinters exists.
7. Employees routinely exposed to noise (30 or more days per year) at or above 80 dBA Time Weighted Average (TWA) shall be placed in a hearing conservation program. Employees shall never be exposed to impact or impulse noise in excess of 140 dB. This program shall consist of the following:
   - Baseline medical monitoring and annual re-examination.
   - Annual training on the types of hearing protection available, use of hearing protection (including limitations), other means of reducing noise exposure, noise monitoring, effects of noise on hearing, purpose of medical monitoring, and care of hearing protectors.
   - Use of hearing protection by employees exposed to continuous noise in excess of 85 dBA TWA.
   - Area noise surveys.

   For more information on hearing protection see Section 2.9.
8. Protective clothing (coveralls, smocks, etc.) shall be used when the possibility exists that an employee's clothing could become contaminated by hazardous materials or when protection is needed against abrasions, heat, or cold.
9. Fall protection shall be used when working at unprotected heights. Employees using fall protection shall be trained annually in the proper care and use of the specific equipment. Safety belts shall not be used for fall protection; harnesses must be used. Belts may be used for fall restraint. Fall restraint is defined as a device that allows the individual to approach a precipice or hazard area, but is short enough to prevent the possibility of an actual fall.

3.6.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.6.6 Reference Documents Unique to this Section

29 CFR 1910.66, *Appendix C, Personal Fall Arrest System*

29 CFR 1910.95, *Occupational Noise Exposure*

29 CFR 1910, *Subpart I, Personal Protective Equipment*

ANSI Z41-1991, *American National Standards for Personal Protection—Protective Footwear*

ANSI Z87.1-1989, *American National Standard Practice for Occupational and Educational Eye and Face Protection*

ANSI Z89.1-1986, *American National Standard for Personnel Protection-Protective Headwear for Industrial Workers—Requirements*

GPG 1700.2, *GSFC Chemical Hygiene Program*

NPG 1821.1, *Hearing Conservation*

3.7 Office Safety

3.7.1 Scope

This section describes the requirements for office safety within the MSD facilities. Although this is written for an office area, the general requirements apply to any area containing desks, file cabinets, etc.

3.7.2 Acronyms/Definitions

1. Carpal Tunnel Syndrome (CTS)—CTS is one type of CTD. There are three main kinds of cumulative trauma disorders (tendonitis, trigger finger, and rotator cuff tendonitus). They often happen near the joints, where tendons rub against ligaments and bones.
2. Cumulative Trauma Disorder (CTD)—Injuries to the musculoskeletal and nervous systems caused by excessively repetitive motion, high force, and awkward body postures.
3. Ergonomics—The study of human characteristics for the appropriate design of the living and work environment.
4. Human Factors—Understanding the user's role in the overall system performance.
5. Video Display Terminals (VDT)—VDTs are comprised of a display screen, a keyboard, and a central processing unit.

3.7.3 General

Although office work is considered non-hazardous, numerous and costly worker's compensation claims are incurred by office workers. Office safety includes not only slips, trips, and falls, but also ergonomics issues. The primary cause of injury in an office setting is complacency.

3.7.4 Design/Operational Requirements

1. Areas shall be provided with adequate illumination. General office areas usually need between 50 and 100 foot-candles. Areas where personnel are working on computers should have lighting levels somewhat lower (i.e., 28–50 foot-candles). Along with reduced levels of lighting, glare on screens should be reduced or eliminated.
2. Extension cords should be eliminated as much as possible. No cord should be run across walkways. (See Section 2.8 for additional requirements for electrical equipment.)
3. All equipment should be inspected prior to use and used only if in good condition. This is especially true for chairs. Only five-legged chairs should be used. Never tilt back on two legs of a chair. Chairs should be adjustable for proper height and back support.
4. Computer stations should be set up to accommodate the worker and eliminate strain. Health effects from using VDT include eyestrain, fatigue, and musculoskeletal problems, such as CTS. OSHA's publication 3092 recommends proper VDT configuration.
5. File cabinets must always be loaded from the bottom up, placing heavier items in the bottom. Never open more than one drawer at a time. Never leave an open file drawer unattended. Never open a drawer if someone is underneath it or in danger from it.

6. Never stand on a chair with casters to reach high. Use a ladder.
7. Housekeeping is extremely important. Pick up debris from the floor. Even something as small as a paper clip or piece of paper can cause slipping hazards.
8. Remove or tape down torn carpets until repaired. Remove loose or curled mats. Wipe up liquid spilled on floors.
9. Do not store items on top of bookcases or cabinets above head height.
10. Do not lift items heavier than you can comfortably lift. The National Institute for Occupational Safety and Health (NIOSH) lifting guidelines state that a person could lift 50 lb (22.7 kg) under ideal conditions in front of the body not involving trunk twisting. Ideal conditions include: smooth lifting (no jerking), the hands spread 30 inches (76 cm) or less, lifting posture unrestricted, and object held close to the body. Additionally, there must be good couplings (handles, shoes, floor surfaces) and a favorable environment. If all of these conditions are not met, the maximum weight must be decreased.

3.7.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.7.6 Reference Documents Unique to this Section

ANSI/IES, RP1-1982, *Practice for Office Lighting*

NPG 8831.2, *Facilities Maintenance Management*

NIOSH *Work Practices Guide for Manual Lifting*

Occupational Safety and Health Act of 1970

3.8 Lockout/Tagout

3.8.1 Scope

This section explains the minimum requirements for lockout/tagout, and securing hazardous energy sources. Energy sources include: mechanical, electrical, hydraulic, pneumatic, chemical, thermal, cryogenic, electromagnetic, and other types of energy.

3.8.2 Acronyms/Definitions

1. Affected employee—An employee whose job requires him/her to operate or use a machine or piece of equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.
2. Hot tap—A procedure, used in the repair or service of equipment, which involves welding on a piece of equipment under pressure in order to install connections or appurtenances. It is commonly used to replace or add sections of pipeline without the interruption of service for air, gas, water, and steam systems.
3. Lockout device—A device that uses a positive means such as a lock (either key or combination type) to hold an energy-isolating device in the safe position and prevent the energizing of the machine or equipment.
4. Servicing and/or Maintenance—Workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, maintaining, and/or servicing machines or equipment.
5. Tagout Device—A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy-isolating device to indicate that the energy-isolating device and the equipment being controlled may not be operated until the device is removed. The device must be substantial enough to prevent inadvertent or accidental removal. It must have a clear warning against the hazardous condition and the name of the worker who placed the lock or tag on the system. The attachment must be environment-tolerant and able to withstand a 50-lb (22.7 kg) force.

3.8.3 General

Lockout/tagout requirements are applicable to a wide range of facilities, systems, subsystems, and equipment, including project-related equipment. These requirements are applicable whenever performing servicing and/or maintenance operations where release of hazardous energy could cause injury or death.

3.8.4 Design/Operational Requirements

1. All new or modified equipment/machinery shall be designed to accept a lockout device.
2. Cord-and-plug-type electrical equipment does not have to be locked out if it is unplugged from the energy source and is under the exclusive control of the employee performing the work.

3. Procedures are required for all lockout/tagout operations, except when all of the following conditions are true:
   - The equipment has no potential for stored or residual energy or re-accumulation of stored energy after shut down;
   - The equipment has a single energy source which can be easily identified and isolated;
   - The isolation and locking out of that energy source will completely de-energize and deactivate the equipment;
   - The equipment is isolated from that energy source and locked out during servicing or maintenance;
   - A single lockout device will achieve a locked-out condition;
   - The lockout device is under the exclusive control of the authorized employee performing the servicing or maintenance;
   - The servicing or maintenance does not create hazards for other employees; and
   - There have been no accidents involving the unexpected activation or re-energization of the equipment during servicing or maintenance.
4. All affected and authorized employees must receive training on the function of energy control devices, procedures, and recognition of hazardous energy sources, and authorized employees shall verify that they have the knowledge and skills to perform the lockout/tagout procedure.
5. Hot taps are allowed only when approved by the Branch Head for one of the following reasons: continuity of service is essential and/or shutdown of the systems is impractical. Procedures shall be written and approved. They shall include special equipment that must be used to protect employees.
6. Keys to lockout devices must be maintained in the control of the person applying the device.
7. Tags are essentially warning devices and may be used only when some other means of securing the energy source is also used (i.e., removal of a fuse, removal of a valve handle, etc.).
8. Affected employees must be notified prior to the application of a lockout/tagout device. If the lockout/tagout removes facility equipment from service, the Branch Head must be notified.
9. After application of a lockout/tagout device, the equipment must be tested to verify that all energy sources have been removed prior to starting work. Testing shall be done by taking circuit readings, operating valves while reading gages, performing normal startup operations, etc.
10. Prior to restoring the equipment to service, procedures shall require an inspection of the area to verify that nonessential items have been removed and all system components are operationally intact.

11. When the authorized employee is unavailable for removal of his/her lock/tag, the device may be removed under the direction of the applicable Section Head or equivalent manager, provided that:
    - Specific procedures and training for the removal have been developed and approved;
    - Every effort has been made to locate the person who applied the device; and
    - The authorized employee is contacted and informed as to the removal of the device prior to removing the device, or immediately upon return to work.
12. Outside contractors performing work in the MSD facility shall have their lockout/tagout program/procedures approved by the applicable Section Head prior to starting work.
13. Where work will be continued into the following shift, the new worker will affix his/her lock and/or tag before the previous shift's worker removes his/hers. The new worker shall then verify that all energy sources have remained secured.
14. When work is performed by more than one person or group, each person or group shall place their locks on the equipment by means of a gang lock, so that the equipment cannot be restored to service until all locks have been cleared.
15. Under no circumstances shall a piece of equipment be operated if it is locked or tagged out unless it is for checkout purposes. In those cases where testing is required, the lockout or tagout may be removed temporarily and the equipment energized when the following occur:
    - The equipment is clear of all tools and materials and the equipment components are operationally intact;
    - The area is secured from access by all non-essential employees;
    - The device is removed by the authorized employee; and
    - Immediately after testing the energy control measures are reapplied.
16. When a group lockout or tagout device is used, one employee shall be appointed as primarily responsible for the whole group. This person shall ascertain the status of all individual group members prior to removal of the device, and each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism prior to the start of work, and remove it when the work is complete. This person's lockout device should be the first one on and the last one off.

3.8.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.8.6 Reference Documents Unique to this Section

ANSI Z244.1-1982, *Requirements for Lockout/Tagout of Energy Sources*

OSHA 29 CFR 1910.147, *The Control of Hazardous Energy (Lockout/Tagout) Subpart S*

3.9 Thermal and Other Heating Devices

3.9.1 Scope

This section covers heat-producing systems and devices.

3.9.2 Acronyms/Definitions

N/A

3.9.3 General

Many systems and devices used in the MSD either require or produce heat in dangerous intensities. These include thermal chambers, furnaces, ovens, hot plates, solar simulators, steam generators and lines, welding operations, and other miscellaneous heating devices.

3.9.4 Design/Operational Requirements

1. Personnel shall post warning signs wherever heated surfaces are exposed or otherwise accessible to other personnel. Where necessary, erect shields or barrier tapes to keep unauthorized personnel away from potentially hazardous areas.
2. Personnel shall wear appropriate PPE (see Section 3.6) when working near heated surfaces or handling heated objects.
3. Operating procedures for walk-in thermal chambers and ovens shall include a checklist item to have the operator conduct a walk-down before operating the facility, to verify that all personnel are out of harm's way.
4. Operators of solar simulators, welding equipment (see Section 3.4), electrical heaters, etc., are responsible for taking measures to protect themselves and other personnel from inadvertent exposure to heat-producing sources.
5. Protection against heat-producing radiation is covered in Sections 2.6 and 2.7.
6. Additional ventilation may have to be provided, if an analysis of the operation indicates personnel would be exposed to harmful levels of heat, which may cause heat stroke or heat exhaustion.

3.9.5 GSFC Contacts

S&EB: (301) 286-2281
AETD Safety Manager: (301) 286-3816
MSD Safety Lead: (310) 286-1034
Support Contractor Safety: (301) 286-1035

3.9.6 Reference Documents Unique to this Section

N/A

Appendix A. Evaluation and Authorization Documents

This appendix contains two documents that are helpful to the user of MSD facilities. Their titles and purposes are listed below:

Title: Figure A-1. MSD System Evaluation Form Cross Referenced by Section
Purpose: This cross reference helps the user find specific Sections of the Safety Manual that provide pertinent information about MSD Evaluation Form topics.

Title: Figure A-2. Authorization and Approval Requirements for MSD Activities
Purpose: This is a listing of forms or documents required to conduct MSD operations with special circumstances. It lists the subject, authorizing source, preparer, and approval requirements.

Figure A-1. MSD System Evaluation Form (Cross Referenced by Section)

MSD System Evaluation Form (Section Number/Topic)	*MSD Safety Manual* (Reference Section Number)
1. **Mechanical Handling**: Crane/forklift operations	2.1.1 (Cranes); 2.1.2 (Slings); 2.1.3 (Forklifts)
a. Personnel beneath suspended load	2.1.1.4.1; 2.1.3.4.4
b. Center of gravity identification	2.1.1.4.1-3
c. Slings marked for SWL/proof load	2.1.2; 2.1.2.4.4
d. Slings certified to NASA-STD-8719.9	2.1.1.4.1-5; 2.1.2
e. Components disassembled/identified	2.1.2.4.4
f. Critical welds inspected	2.1.1.4.2
2. **Ordnance**: EEDs, pyrotechnics, pyrophorics	2.2
a. Ordnance firing in MSD facilities	2.2.4
3. **Pressure & Vacuum Systems**: Ground/flight systems	2.3.1 (Ground); 2.3.2 (Flight)
a. Proof pressure tests for MSD facilities	2.3.1.4
4. **Stored Energy Devices**:	2.4
a. Systems (springs, booms, etc.)	2.4.2
b. Non-solid-state gyros	2.4.2.4.5
c. Solar array or other deployments	2.4.2.4.4
d. Reaction wheel operations	2.4.2.4.5
e. Batteries	2.4.1
f. Kinetic or rotational systems	2.4.2.4
g. Pyrophoric devices	2.5.4.9
5. **Hazardous Materials & Hazardous Wastes**: Harmful fluids/solids	2.5
a. Flammable/combustible	2.5.4
Toxic	2.5.4
Corrosive	2.5.4.17
Reactive	2.5.4
Cryogenic	2.5.4.15
Explosive	2.5.4
Oxidizer	2.5.4.8
Health hazards	2.5.4
b. Personnel entering confined spaces	2.11
c. Systems with temperature extremes	2.5.4
d. Materials w/air contamination hazards	2.5.4
6. **Non-ionizing Radiation Systems**: EMI systems (RF, lasers, UV radiation, microwave, etc.)	2.6
a. RF systems radiating to free space	2.6.5
b. >100 mw outside a shielded enclosure	2.6.5
c. Class IIIB or IV lasers	2.6.5.3
d. Other non-ionizing radiation sources	2.6.5
7. **Ionizing Radiation Systems**: (NRC licensed sources, x-ray producing machines, particle accelerators, accelerator produced radioisotopes, radium and offshoot products)	2.7
8. **Electrical Systems & Equipment**: Systems, subsystems, equipment.	2.8
a. Commercial equipment	2.8.5-6
b. Non-commercial or modified commercial equipment	2.8.5-6, 2.8.10
c. Equipment grounding	2.8.9
d. Equipment with exposed, live components	2.8.10
e. Equipment fuses/breakers	2.8.10
f. Connector foolproof keying	2.8.10
9. **Noise**: Systems create noise > 85 dBA	2.9

Figure A-1. MSD System Evaluation Form (Cross Referenced by Section)

***MSD System Evaluation Form* (Section Number/Topic)**	***MSD Safety Manual* (Reference Section Number)**
10. **Unique/Experimental Systems**: Potentially hazardous systems not addressed above	2.10

Figure A-2. Authorization and Approval Requirements for MSD Activities

Subject	Authorizing Source	Form or Document	Prepared By	Approved By
Non-ionizing Radiation Systems	GHBs 1860.2 (RF) 1860.3 (LASER) 1860.4 (UV)	Form 23-6RF Form 23-28RF Form 23-6L Form 23-28L Form 23-35LU	Requesting Project Manager	Health Physics Office
Ionizing Radiation Systems	GHB 1860.1	Form 23-6I Form 23-28I Form 23-35IP Form 23-6ID Form 23-28ID	Requesting Project Manager	Health Physics Office
Flight Weight Pressure Systems	NSS/HP 1740.1	Formal Certification Report (1740.1)	Requesting Project Manager	MSD (Branch Head Title)
Medium Weight Pressure Systems	NSS/HP 1740.4	Formal Certification Report (1740.4)	Requesting Project Manager	MSD (Branch Head Title)
Hot Work Permit		Form 23-4 Form 23-4A Utility Outage Request Form	Employee or Supervisor (Same)	S&EB (or MSD designee) FMD
Confined Space Entry Permit	OSHA 29 CFR 1910.146 & GMI 1780.1	Form 23-52	Employee or Supervisor	MSD (Title) or Designee
Hazardous Waste Disposal	Code 205.2, S&EB	Form GSFC 23-54	Employee or Supervisor	Hazardous Waste Environmental Office
Incident or Mishap	GPG 8621.1 GPG 8621.2 GPG 8621.3	NASA Form 1627A NASA Form 1627	Employee's Supervisor	MSD (Division Chief Title)
Lift Operator Certification	GMI 1710.6 NASA-STD-8719.9	Certification Card	RECERT Manager	RECERT Manager
Critical Lift Failure Modes Effects Analysis (FMEA)	GMI 1710.6 NASA-STD-8719.9	Formal FMEA Report	User's Supervisor	RECERT Manager and MSD (Title)
Waivers (e.g., Code 3 Weather Operations, Stress Factor of Safety <3.0 on Yield, etc.)	NASA, Goddard, or MSD Policy	Written Request Form with Justification	Requesting Project Manager or Employee's Supervisor, as applicable	Project Manager and/or MSD (Branch Head Title)

Appendix B. Mishaps/Incidents

This appendix contains the information and documents needed to comply with the MSD mishap and incident reporting requirements.

Mishaps/Incidents

B.1 Scope

The reporting procedures for mishaps and incidents are specified in NASA NPG 8715.3 and NPD 8621, *NASA Procedures and Guidelines for Mishap Reporting, Investigation, and Recordkeeping*. The requirements of these two documents are summarized below.

B.2 Definitions

1. NASA Mishap—Any unplanned occurrence, event, or anomaly that meets one of the definitions below. Injury to a member of the public while on NASA facilities is also defined as a NASA mishap.
   - Type A Mishap—A mishap causing death and/or damage to equipment equal to or greater than $1,000,000. Mishaps resulting in damage to space hardware (flight and ground hardware) and/or unanticipated test failures are included in this definition (and the definitions listed below).
   - Type B Mishap—A mishap resulting in permanent disability to one or more persons, or hospitalization (for other than observation) of five or more persons, and/or damage to equipment or property between $250,000 and $1,000,000.
   - Type C Mishap—A mishap resulting in damage to equipment or property between $25,000 and $250,000, and/or causing occupational injury or illness which results in a lost workday case.
   - Mission Failure—Any mishap of such a serious nature that it prevents accomplishment of a majority of the primary mission objectives (as determined by an authorized assessment board).
   - Incident—A mishap consisting of less than Type C severity of injury to personnel (but more than first aid severity) and/or property damage between $500 and $25,000. Events that result in property loss of less than $500 should be reported as incidents if they have significantly greater potential or high visibility.
2. NASA Contractor Mishap—Any mishaps as defined in Paragraph 1 above that involve only NASA contractor personnel, equipment, or facilities in support of NASA operations.
3. Immediately Reportable Mishaps—All mishaps that require immediate telephonic notification to local and Headquarters' safety officials. Included in this category are those mishaps defined in Paragraphs 1 and 2 above with the exception of Type C injury/illness cases and incidents.
4. Close Call—An occurrence in which there are no injuries, no property/equipment damage, and no significant interruption of productive work, but which possesses a high potential for any of the mishaps defined above.
5. OSHA as Recordable Mishaps—An occupational death, injury, or illness that must be recorded subject to OSHA requirements in 29 CFR Part 1904.

B.3 Mishap/Incident Reporting Requirements

Any mishap, incident, or close call situation which has the potential to injure personnel, damage critical hardware, or result in MSD facility equipment failure, shall be reported by the affected area's supervisor on the MSD Incident Report Form (Figure B-1) within 24 hours of the occurrence and on the GSFC Close Call Reporting system found at web site http://safety1st.gsfc.nasa.gov/closecall.htm. Close call reports are tracked through closeure by S&EB. Close call reports are used to document not only mishaps and near-misses, but also safety related items that can not immediately be fixed or affect other areas on Center. The S&EB generate SAF Alerts when need from the close call reports. Additionally, the NASA Mishap Report, Form 1627A and 1627 (found on web site https://extranet.hq.nasa.gov/nef/user/form_search.cfm), shall be completed per the requirements of NPG 8715.3 and NPD 8621 for all injuries and near-misses. The center Chief shall be informed no later than 8:30 AM on the day following a reportable incident. If information is incomplete, an initial report should be submitted to meet the deadline, followed by the final report. It is important to complete the corrective action section and describe what positive steps will be taken to prevent future recurrence of the problem.

Copies of the report shall be distributed to the center Office, affected Branch, Center Safety Committee, S&EB, and appropriate organizational elements.

B.4 Mishap Investigation and Follow-up

Affected organizations are responsible for investigating mishap causes and instituting corrective measures to prevent recurrence. In particular, investigation boards shall be appointed for mishaps categorized as Type A, Type B, or Mission Failure. Investigations conducted by the boards will be documented formally and the reports distributed for mishap prevention purposes. Refer to NPD 8621 for the complete requirements for mishap investigation and follow-up.

Figure B-1. MSD Incident Report Form

Code 549 INCIDENT REPORT				**No. MT-IR-02-**
(1) Title:				
(2) Incident Date:	**(3) Time**:		**(4) Location**:	
(5) Project/Activity	**(6) WOA**	**(7) Procedure**	**(8) NCR**	**(9) NASA Mishap Report**
(10) Personnel Involved:	**(11) Affiliation**	**(12) Injury**		
(13) Equipment:				
(14) Problem Description:				
(15) Immediate Corrective Action:				
(16) Task Leader Approval:				
(17) Corrective Action				
(18) Follow Up				
(19) Approval: Code 549 Branch Head: **Other Approvals:**		**Eye Witness:**		**Responsible Manager/Supervisor:**
Verified Effective:		**Originator:**		

B.5 Immediate Responsibilities Following a Mishap

1. Personnel first on the scene of a mishap:
   - Call Goddard's emergency telephone extension, 911, and request assistance. If possible, render assistance to victims and attempt to limit further injury and property/equipment damage.
   - If possible, and until relieved by competent authority, secure the scene of the mishap against action that could impair investigation, and obtain the names and addresses of witnesses.
   - Report by telephone or the most expeditious means all known facts to the S&EB, (301) 286-2281.
2. Area Supervisor/Group Leader:
   - Obtain immediate medical assistance for injured personnel. Institute appropriate emergency measures to minimize further damage to personnel and property.
   - Render assistance to the emergency response personnel as requested.

   Obtain all information necessary to fulfill the reporting requirements described in Section B.3 above. Ensure that the S&EB has been notified.

Appendix C. Pressure Vessels and Pressurized Systems

This appendix contains requirements for designing, operating, modifying, repairing, and certifying pressure vessels and pressurized systems (PV/S). It provides additional details not contained in Section 2.3 of this Safety Manual. Section 2.3 deals primarily with the general safety aspects and GSFC-required certifications of PV/S, whereas this appendix contains specific technical information for designing, maintaining, and operating these systems.

Detailed Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PV/S)

C.1 Scope

This Appendix covers detailed requirements for ground-based PV/S, including vacuum systems, in permanent or temporary configuration. Topics addressed herein are not all inclusive, but represent a compilation of Code requirements and good engineering practice.

C.2 Design/Operational Requirements

1. Loadings:

   All PV/S shall be designed for at least the most severe condition of coincident pressure and temperature expected in operation. In addition to pressure, the effects of the following loadings shall be considered in the design:

   a. Weight of the PV/S and its contents.

   b. Static reactions from the weight of attached equipment.

   c. Cyclic and dynamic reactions caused by pressure or thermal variations, flow-induced vibrations, or attached equipment and mechanical loadings.

   d. Wind, snow, ice, and seismic reactions.

   e. Impact reactions such as those due to fluid shock.

   f. Temperature gradients and thermal expansion.

2. Temperature:

   The temperature used in the design of a PV/S shall not be less than the mean metal temperature (through the thickness) expected under operating conditions. If necessary, the metal temperature shall be determined by computation using accepted heat transfer procedures, or by measurement of equipment in service under equivalent operating conditions.

3. Materials Selection:

   Only materials listed by appropriate codes, standards, and technical literature as compatible for each specific service shall be selected. All operating conditions such as temperature, pressure, fluid compatibility, and environmental location must be considered prior to material selection. Materials selected shall be compatible with each other as well as with the service fluid. When operating temperatures vary greatly, care shall be taken to consider the stresses caused by thermal expansion.

4. Welded Designs:

   All weldments in a PV/S, including attachments made to pressure retaining boundaries, shall be designed to the requirements of the applicable ANSI/ASME B31 *Pressure Piping Code* and/or ANSI/ASME *Boiler & Pressure Vessel Code*. Drawings and/or design specifications

used for welded assemblies shall contain complete information detailing joint geometry; weld type, size, and location; material type and specification; preheat, interpass, and postweld heat treatments; and the appropriate nondestructive testing requirements. All welding symbols shall meet the requirements of ANSI/AWS A2.4, *Symbols for Welding and Nondestructive Testing*, latest edition.

5. Overpressure Protection Requirements:
    a. General Requirements:
        (1) All pressure vessels and piping/tubing systems shall be equipped with the requisite overpressure protection devices, meeting the requirements of the applicable design code, and must be selected on the basis of their intended service.
        (2) All overpressure protection devices shall be set to function at or below the MAWP of the vessel or MDP of the piping/tubing system.
        (3) The capacity of overpressure protection devices shall be sized to prevent pressure from rising more than 10% or 3 psi (20.7 kpa), whichever is greater, above the MAWP of the vessel or MDP of the piping/tubing system.
        (4) All overpressure protection devices shall be installed in such a manner that they are readily accessible for inspection and cannot be rendered inoperative.
        (5) All new relief valves shall have their set points certified by the RECERT Manager prior to being placed in service.
        (6) All overpressure protection devices shall be periodically tested and inspected in accordance with the Inservice Inspection requirements of GMI 1710.4.
    b. Specific Requirements:
        (1) In order to avoid simmering, pressure relief valve set points should be specified to be a minimum of 30 psig (206.8 kpa) above normal operating pressure of the vessel or piping/tubing system when operating at or below 300 psig (2,069 kpa), and 10% above normal operating pressure of the vessel or piping/tubing system when operating above 300 psig (2,069 kpa.) In no case shall the relief valve set point exceed the MAWP of the vessel or MDP of the piping/tubing system.
        (2) In order to avoid premature creep-induced failure of a rupture disk, the burst point should be selected to be at least 30% above the normal operating pressure of the vessel or piping/tubing system. In no case shall the burst point of a rupture disk exceed the MAWP of the vessel or MDP of the piping/tubing system when the rupture disk is the sole source of overpressure protection.
        (3) Overpressure protection devices used in systems operating at or near temperatures and pressures where a phase change could occur (cryogenic systems, steam systems, condensate systems, etc.) shall be selected to ensure adequate discharge capacity.

(4) Relief valves of adequate capacity shall be installed in all cryogenic piping/tubing segments located between isolation or control valves.

(5) The discharge of relief valves located on indoor cryogenic systems must be diverted or piped away from personnel and equipment. Relief valves which do not provide for attachment of discharge piping/tubing shall not be used.

(6) Adjustable-type relief valves shall not be used on any piping/tubing system without the prior written approval of the RECERT Manager.

6. Piping Flexibility:

   Piping systems shall be designed to have sufficient flexibility to prevent thermal, mechanical, or acoustically-induced expansion, contraction, or vibration from causing any of the following:

   a. Failure of piping or supports from overstress or fatigue.
   b. Leakage at joints.
   c. Detrimental stress or distortion in piping or in connected equipment.

7. Piping Support Requirements:

   All piping systems shall be structurally supported to prevent the development of excessive piping stresses, leakage at joints, excessive loads on connected equipment, and resonance due to flow and wind-induced vibrations. The location, spacing, and design of supporting elements in uncomplicated systems may be based upon simple calculations, applicable code requirements, and good engineering practice. Complicated piping systems will require more extensive engineering analyses to address the stresses, moments, and reactions imposed by service pressure and temperature variations, shock loads, vibration loads, and hydrostatic testing loads.

C.3 Special Requirements for Compressed Air Receivers

The requirements contained in this section are specific to the procurement of compressed air receivers and shall be followed by all GSFC organizational elements. Deviations will require a waiver in accordance with GMI 1710.4.

1. Purchase specifications for all new compressed air systems containing Tank Mounted Air Compressors (TMACs) must specify that the compressed air receiver meets the requirements of the ASME *Boiler & Pressure Vessel Code*, Section VIII, Paragraph UG-22 and must be so documented by the manufacturer. In accordance with the recommendations of the National Board of Boiler and Pressure Vessel Inspectors, if documentation is not provided the compressor/motor shall be removed from the vessel and mounted separately. Connections between the compressor and receiver should be 300 psi (2,069 kpa) minimum flex hose.
2. In compliance with OSHA, 29 CFR 1910.169, purchase specifications for all new compressed air receivers must state that the receiver be designed, constructed, tested, and stamped in accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code*.
3. Purchase specifications for all new compressed air receivers must include the requirement that the supplier furnish to the GSFC organization purchasing the receiver a copy of the Manufacturer's Data Report, Form U-1 or Form U-1A as applicable, at the time of receiver delivery (Section VIII, Paragraph UG-120).
4. Prior to initiating procurement of a new compressed air system, the purchasing organization shall contact the RECERT Manager to obtain the applicable corrosion allowance, which must be specified per Paragraph UG-25 of Section VIII of the ASME *Boiler and Pressure Vessel Code*.

C.4 System Modifications

All modifications to PV/S void the system's certification. The following are requirements that must be met in order for the modified system to be recertified and placed into/returned to service by the system owner:

1. The design, installation, inspection, and testing of the modified PV/S is in accordance with the applicable consensus code and NASA documentation.
2. The proposed modification is submitted by the system owner to the RECERT Manager for approval prior to execution. The submittal shall be in sufficient detail that the RECERT Manager can perform an independent Code compliance review.
3. The documentation specified in GMI 1710.4 shall be provided by the system owner to the RECERT Manager prior to placing the modified PV/S back in service.
4. Upon completion of the modifications, the system owner must notify the RECERT Manager to arrange for system certification tests and inspections. System certification must be granted by the RECERT Manager prior to placing the modified system back in service.
5. As-built system configuration drawings showing the changes made in the system or system components shall be transmitted by the system owner to the RECERT Manager no later than two weeks after completion of the modification.

C.5 Component Repair/Replacement

1. Repairs:
   a. All repairs to a PV/S that involve welding, brazing, or soldering on a pressure retaining boundary or "plugging" of leaks using any other method shall be reviewed and approved by the RECERT Manager prior to the start of the work.
   b. Repairs of a preventive or corrective maintenance nature such as repair/replacement of packing, seals, seats, etc., on valves (other than relief valves) and pumps do not need prior RECERT Manager review and approval.
   c. No repairs to PV/S overpressure protection devices shall be made.
   d. Any repair to a PV/S pressure-indicating gage requires that the gage be recertified prior to reinstallation.
2. Replacements:

Replacement of individual components in a PV/S requires the prior review and approval of the pertinent design data by the RECERT Manager. In addition, replacement relief valves and pressure gages shall be certified by the RECERT Manager prior to installation.

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	03/10/2004	Initial Release